Learners' numeracy progression and the role of mediation in the context of two after school mathematics clubs

By

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Statement of Original Authorship

The work contained in this thesis has not been previously submitted to meet requirements for an award at this or any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

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ABSTRACT

National and international assessment results, research studies and reports point to South Africa as having educational challenges, specifically with mathematics, science and language. Addressing some of these issues is a key aim for the SANC project at Rhodes University, the context in which this study takes place. Working from a broad Vygotskian perspective of learning and development, this study had a dual focus and investigated how Grade 3 learners' mathematical proficiency progressed (or not) whilst participating in after school maths clubs over the course of a year, and explored how the mediation offered in the clubs enabled or constrained the emergence of zones of proximal development (ZPD) and thus learning for the club learners.

Methodologically, this study works within a largely qualitative, interpretive research paradigm and is designed using a longitudinal case study research strategy. Two after school maths clubs formed the empirical field. The study drew on a range of data collection methods to investigate the dual nature of the research questions for Grade 3 learners. Examples include adapted one-to-one mathematical proficiency interviews and paired task-based interviews. The study highlighted the relationship between the multiple roles I played both within the research study and within the SANC project context and emphasises the influence and future implications for these various roles within the SANC project and beyond in terms of my own role as club mentor, for the future design of the SANC project maths club programme and for broader teacher and club facilitator development within and beyond the project.

This study has offered insight into how mathematical proficiency may develop in Grade 3 South African learners and as such is an important contribution to the newly developing field of both numeracy and primary educational research in Southern Africa. Additionally, the research findings point to the clubs, as an example of an out-of-school time (OST) programme, providing potentially enabling spaces for both recovery and extension of mathematical proficiency in learners as these spaces are free from several contextual constraints that teachers face in their classrooms.

Furthermore, it was found that learners showed development of their conceptual understanding, procedural fluency and adaptive reasoning as proposed by Kilpatrick, Swafford and Findell (2001). The use of various elements of the Maths Recovery (MR) programme (Wright, 2003) in the research process has highlighted various important contributions for broader research. For example, the need to investigate less time consuming approaches to both diagnostic assessment and learner mathematical profiling.

Findings from this study support Meira and Lerman’s (2001, 2009) recently developed notion that catching attention is key to the creation or emergence of a ZPD. The study found that a combination of ‘*attention catching’* and ‘*tuning in’* enabled the creation (emergence) and sustainment of ZPDs in club learners. The study proposed the notion of *tuning in* where participants in a mathematical interaction continually adjust to each other in order to communicate mathematically. Furthermore, the study found that when attention is not caught or the participants are not tuned in, the learning activity may still be useful in assisting learners to consolidate their existing learning and / or build confidence and as such is particularly relevant to the South African context where fluency in calculating is weak (Hoadley, 2012; Schollar, 2008). This emergent notion of ‘*flow*’ additionally can play a supporting role in the emergence of a ZPD. The study also found that the *manner* in which the mediation was offered is important. The results show that the mathematical contributions learners make during interactions captured the mentors’ attention and resulted in mediation that was intentional but spontaneous, flexible, responsive and in-the-moment.

This study makes theoretical and methodological contributions to various aspects of mathematics education research particularly with regard to how ZPDs emerge and are sustained and how mediation is offered to facilitate the emergence of ZPDs. Additionally, some aspects of the Learning Framework in Number (LFIN) as part of the Maths Recovery programme have been extended to work in a South African after school club context and to provide useful information for both learner progression over time and for planning of club activities. As such this study thus also contributes to the newly developing field of primary mathematics research in South Africa and to the body of research on primary after school learning programmes both locally and internationally.

Keywords: Numeracy progression, numeracy, mediation, after school maths clubs, Zone of Proximal Development, attention catching mechanisms, out-of-school time programmes, primary school

ACKNOWLEDGEMENTS AND THANKS

First and foremost, I would like to thank both the learners who participated in my research clubs in 2012 and the schools that hosted the clubs. Without the willing participation of the learners and the schools, it would not have been possible to undertake this study.

My supervisor and Chair, Mellony Graven has been a blessing. Not only did she conceptualise the maths club space which forms the empirical field for this study, but she has tirelessly shared her research and teaching experiences with me throughout this journey. Our close working relationship in the project has meant that we have shared a common passion for working with learners in the clubs. We set up the pilot club together, she mentored my clubs for me when I was ill and she was a co-facilitator for learner task-based interviews. Added to all that, she has supervised and meticulously read my work and has encouraged me to publish as I have gone along. Mel, I cannot thank you enough for everything you have done for me during this process!

Steve Lerman has kindly read various sections of this thesis and has given freely of his time and experience in discussion of some of issues I faced during my research journey. He has provided me with much needed “nuggets” of wisdom and clarity when I really needed them, helping me see the wood for the trees. Thank you Steve.

Varonique Sias is the SANC project manager. I would like to thank her for listening to me talk endlessly about my study, for assisting me with learner Mathematical Proficiency interviews during data collection and for sorting out small details related to the admin processes of a PhD.

My son Thomas has been very supportive and has both accepted and alternately tolerated his mother studying for 3 and half years. I hope that one day he will study for his doctorate too. Although my family and friends are scattered around the globe, they have given me encouragement and support from near and far.

Our numeracy research and development work is supported by the South African Numeracy Chair Initiative of the FirstRand Foundation (with the RMB), Anglo American Chairman’s fund, Department of Science and Technology and the National Research Foundation. I am immensely grateful to these organisations for providing funding for my study and for my work in the SANC project.

Mellony has stressed that a key aspect of a doctoral thesis is the process of sharing, engaging and networking with various communities along the way. I have endeavoured to do this through attending and presenting at local and national conferences, publishing in peer-reviewed journals, in teacher-focused publications and in local newspapers. I would like to thank everyone who co-authored and co-presented papers with me and who reviewed and provided feedback on long papers and journal publications. Thanks too to the people who reviewed and gave feedback on papers and articles.

Since I began my doctoral research in 2011, I have attended a number of conferences and presented papers. SAARMSTE is the Southern African Mathematics, Science and Technology research association. AMESA is a forum for South African mathematics teachers whilst SARAECE focuses on Early Childhood Education in South Africa. Each organisation has regional, provincial and national chapters and I have presented in all of these forums. Many of the presentations have been co-presented with my supervisor or teachers from the SANC project teacher development programme on a range of topics such as starting maths clubs, games for mental maths session and family maths events.

I have also presented the following long peer-reviewed papers at national conferences:

Conference	Presentation Title	Further details
AMESA 2013	**Quantifying qualitative numeracy interview data**	Stott, D. & Graven, M. In Z. Davis & S. Jaffer, eds. *Proceedings of the 19th Annual Congress of the Association for Mathematics Education of South Africa*, Vol. 1. Bellville, Cape Town: Association for Mathematics Education of South Africa (AMESA), pp. 194–208.
SAARMSTE 2013	**Procedural spectrums: translating qualitative data into visual summaries.**	Stott, D., & Graven, M. In M. Ogunniyi, O. Amosun, K. Langenhoven, S. Kwofie, & S. Dinie (Eds.), Making Mathematics, Science And Technology Education, Socially And Culturally Relevant In Africa: Proceedings Of 21st Annual Meeting Of The Southern African Association For Research In Mathematics, Science And Technology Education (pp. 55–66). Cape Town: University of the Western Cape (UWC).
SAARMSTE 2012	**Design Issues for Mathematics Clubs for Early Grade Learners**	Graven, M. and Stott, D. In Nampota, D. & Kazima, M. (eds) Proceedings of the twentieth annual meeting of the Southern African Association for Research in Mathematics, Science and Technology Education, pp 94-105 University of Malawi, Lilongwe.
AMESA 2012	**Conceptualising procedural fluency as a spectrum of proficiency.**	Graven, M., Stott, D. In Nieuwoudt, S., Laubscher, D. and Dreyer, H. (eds) Proceedings of 18th Annual National Congress of the Association for Mathematical Education of South Africa (AMESA), pp. 146-156 North-West University, Potchefstroom

I have been fortunate to co-author three papers in locally accredited journals with my supervisor during my doctoral study. These are shown below.

Journal	Article Title	Further details
Perspectives in Education 2013	**Research tensions with the use of timed numeracy fluency assessments as a research tool.**	Stott, D., & Graven, M. *Perspectives in Education: Special Issue on Primary Mathematics*, *31*(3), 79–93.
AJRMSTE 2013	**The Evolution of an Instrument for Researching Young Mathematical Dispositions.**	Graven, M., Hewana, D. & Stott, D., *African Journal of Research in Mathematics, Science and Technology Education*, 17(1-2), pp.26–37
Pythagoras 2013	**The dialectical relationship between theory and practice in the design of an after school mathematics club**.	Stott, D., & Graven, M. *Pythagoras*, *34*(1), 10 pages.

Learning and Teaching Mathematics is a teacher-focused journal that is published about 4 times a year. I have shared the following in this publication:

Publication	Article Title	Further details
LTM	**Stomp-Tap-Clap-Snap: A game for promoting conceptual place value and listening skills**.	Stott, D., 2013. *Learning and Teaching Mathematics*, 15, pp.31–32.
LTM	**Quick Tool for Tracking Procedural Fluency Progress in Grade 2, 3 and 4 Learners**.	Stott, D., 2013.A *Learning and Teaching Mathematics*, (14), pp.36–39.
LTM	**Number Line Image Generator – A Website Review**.	Stott, D., 2013. *Learning and Teaching Mathematics*, (14), pp.22–25.
LTM	**Exploring Online Numeracy Games for Primary Learners: Sharing Experiences of a Scifest Africa Workshop**.	Graven, M., Stott, D. (2011). *Learning and Teaching Mathematics*, August 2011. 10 - 16

In 2012 Mellony Graven and I co-authored a weekly Fun with Maths activity series in our local newspaper. In 2013 I authored the activities myself.

Publication	Article Title	Further details
The Teacher 2014 (January)	**Engaging families in maths** (article)	Graven, M., & Stott, D. *theTeacher*, pp. 6 & 8. Johannesburg.
Grocotts 2014	**After school maths clubs add up to learning + fun** (article)	Stott, D. *Grocotts Mail*, p.14.
Grocotts 2013	**Make It Count Series** (weekly activity pages)	Stott, D. *Grocotts Mail*, different pages each week
Grocotts 2013	**Fun with Maths Series** (weekly activity pages)	Graven, M., & Stott, D. *Grocotts Mail*, different pages each week.

Acronyms and terms used in this thesis

Acronym	Description
ACM	Attention catching mechanisms
ANAs	Annual National Assessment(s) (South Africa)
AR	Adaptive Reasoning
BNWS / BNS	Backward Number Word Sequences / Backward Number Sequence
CAPS	Curriculum and Assessment Policy Statement (South Africa)
CU	Conceptual Understanding
DBE / DoE	Department of Basic Education / Department of Education (South Africa)
DEST	Department of Education, Science and Training (Australia)
FNWS / FNS	Forward Number Word Sequences / Forward Number Sequences
LFIN	Learning Framework in Number
LOLT	Language of Learning and Teaching
MP	Mathematical Proficiency
MR	Mathematics Recovery
NICLE	Numeracy Inquiry Community of Leader Educators (SANC Project)
OST	Out-of-school-time
PF	Procedural Fluency
SANC project	South African Numeracy Chair Project (at Rhodes University)
SC	Strategic Competence
TIMSS	Trends in International Mathematics and Science Study
ZFM	Zone of Free Movement
ZPA	Zone of Promoted Action
ZPD	Zone of Proximal Development
ZT	Zone Theory

See also the Glossary on page 398 for definitions of some of these acronyms.

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CHAPTER 1
INTRODUCTION: RATIONALE, SIGNIFICANCE & PURPOSE OF THE STUDY

This opening chapter outlines the background, context and purpose of this research study. I also describe the significance and scope of this research and provide definitions of key concepts used. Lastly, I include an outline of the thesis.

1.1 CONTEXT AND RATIONALE FOR THE STUDY

The South African Numeracy 'Crisis'

South Africa is perceived both locally and internationally as having educational problems, specifically with mathematics, science and language (Fleisch, 2008; Reddy, 2006). This perception is based on results from national and international assessment results (for example: South African matriculation results and the 2011 Trends in International Mathematics and Science Study), from national research studies (for example Carnoy et al., 2011) and from reports on the state of education in our country (for example Taylor, Fleisch, & Shindler, 2008). This study is located within the broader context of mathematics education in South Africa and more specifically within the development of mathematical proficiency in Grade 3 learners in after school maths clubs in the Grahamstown area of the Eastern Cape. My discussion of the context and rationale of the study therefore focuses on issues of numeracy at primary school level in the South African and Eastern Cape context.

Although 20 years have passed, problems that arose from the legacy of apartheid in South Africa still persist. While the government has improved access to schooling, the "quality of the outcomes of both the primary and secondary systems remains an issue of great national concern" (Schollar, 2008 p. 4). Another major factor is that since 1994, the South African education system has undergone substantive and varied curriculum changes, with Curriculum 2005 introduced in 1997 (National Department of Education, 1997) and the latest Curriculum and Assessment Policy Statement (CAPS) introduced in 2011 (Department of Basic Education, 2011a).

The South African government itself notes these various problems, shown for example in these excerpts from a speech given in September 2011 by the General Secretary of the Congress of South African Trade Union (COSATU):

> *Whilst we have made tremendous progress on many areas, […] we have not succeeded on transforming the education system in both quality and quantity. Apartheid fault-lines remain stubbornly in place in our education system. Children born to poor parents remain trapped in an inferior education with*

> *wholly inadequate infrastructure; […] the National Planning Commission says 88% of African schools are regarded as dysfunctional* (COSATU, 2011)

The issues with South African education and particularly it's performance are widely publicised in reports, papers, books and news articles (see for example Fleisch, 2008; Schollar, 2008; Spaull, 2013; Taylor, 2008). Fleisch (2008) tells the story of this 'crisis' in the South African primary education sector and focuses particularly on literacy and numeracy. Similarly a paper commissioned by the Presidency (Taylor, Fleisch and Shindler, 2008) echoes Fleisch's view, stating that poor progress of students in high school and further education is due to the inadequate preparation of primary learners, particularly in literacy and numeracy. Schollar (2008) adds:

> *National and international comparative data has conclusively demonstrated that the vast majority of South African learners are performing well below the minimum expected competence levels for their respective grades.* (p. 1)

South Africa has participated in numerous international comparative studies but for simplicity, I illustrate this poor performance by referring to the results from one such international study and one recent national assessment. In the international TIMSS study carried out in 2011 (HSRC, 2011), South African grade 9 learners scored in the bottom three countries along with Botswana and Honduras. The South African TIMSS report reveals that the Eastern Cape is the lowest performing province. Additionally, nationally 24% of learners report "low confidence" on learning mathematics (p. 10).

From a national perspective in 2008, the Department of Education launched a four-year *Foundations for Learning* (FFL) campaign (Department of Education, 2008) which brought a specific focus to improving reading, writing and numeracy in South African learners. National evaluations in literacy and numeracy (called the Annual National Assessments or ANAs) are a key aspect of this FFL campaign and were first administered nationally in 2011 to Grades 1 to 6 and 9. The ANAs are a key part of the annual school evaluation cycle and from the Department of Education's point of view are explicitly focused on monitoring learner performance in literacy/language and numeracy/mathematics by providing system-wide information on learner performance aimed to allow for comparisons between schools, districts and provinces (Graven, 2013b) and for empowering parents with information about their children's performance in these focus areas (Eastern Cape Department of Education, 2011).

Spaull (2013a) points out that the ANAs are an important mechanism for improving the quality of education in South Africa but argues that "their current implementation and lack of external verification reduces much of their value" (p. 4). The first ANA results in 2011 were poor (Department of Basic Education, 2011b). The most recent 2013 Annual National Assessment report (Department of Basic Education, 2013) states that nationally, there are increases in results for mathematics in all grades from 2013 except grade 1 (a decrease) and grade 4 (which stayed the same). The 2013 ANA report shows an increase in the number of learners achieving 50% or more for both grades 3 and 6. Spaull (2013b) raises concerns about the validity of the 2013 results stating

> *the results need to be comparable across grades, over time and between geographical locations. Unfortunately, given the sorry state of affairs that is the 2013 national assessment, none of these criteria are currently met (unpaged)*

Looking specifically at the 2013 Eastern Cape ANA results, the grade 3 average shows an increase of 10.1% to 50.6%, positioning the Eastern Cape in sixth place out of nine provinces. Additionally 20% more grade 3 learners are scoring 50% or more (54.5%). However, the grade 4 picture is less optimistic. The Eastern Cape still sits in 6th place but shows a decreased average from 2012 by 2.7% to 32.6%. The number of grade 4 learners achieving 50% or more has also decreased by 1.8% to 20.9%. This means that almost 80% of grade 4 learners in the Eastern Cape are not passing the ANAs or are not at the expected grade level. The picture worsens for grades 5 and 6 and shows that by grade 9 only 3.3% of the learners are achieving 50% or more, indicating that grade 9 learners do not have the required knowledge to be in that grade. In spite of these results however, as Schollar (2008) points out:

> *learners are routinely promoted from one grade to the next without having mastered the content and foundational competences of preceding grades, resulting in a large* **cognitive backlog** *[emphasis added] that progressively inhibits the acquisition of more complex competencies (p.5).*

This 'cognitive backlog' compounds the problem of poor performance as many classes can be considered multi-grade classes. As a result, classrooms have a large range of learner levels making it difficult to “consistently teach to the required assessment standards for any particular grade” (Schollar, 2008, p. 5) as teachers need to address the gaps in learners’ mathematical knowledge which should have been grasped in earlier grades (Carnoy et al., 2011).

If the ANAs are intended to assist teachers, district and provincial staff with improving teaching and learning, why are they not informing teaching practices? Graven (2013b) argues that on-going assessments such as the ANAs are doing little to improve either teaching practice or learning and that their introduction simply “indicates increased monitoring of the ‘crisis’ in education” (p. 3). The Eastern Cape Provincial Remedial Plan and Improvement Strategy (Eastern Cape Department of Education, 2011) provides guidance for the analysis of the ANA results at provincial and district levels. However, it is problematic that while the ANA results reveal to teachers that their learners are not at the required grade level they do not assist them to find out which level they are at, in order for them to remediate effectively.

Furthermore, Graven and Venkatakrishnan (2013) found that one unintended consequence of the ANAs across the two South African Numeracy Chairs[1], is that during 2012 an average of four weeks of teaching time was taken up with the preparation (using published exemplars) and writing of the ANAs. In this situation, improved performance in some grades may be a result of test training rather than improved skill levels.

These ANA results and related issues are problematic for the mathematics situation in South Africa and specifically for the Eastern Cape. My study is located against this broader backdrop of poor performance in mathematics and numeracy.

A review of the issues raises a persistent question: why does our country perform so badly in assessments such as these? Numerous studies and reports (Carnoy et al., 2011; Hoadley, 2012; McCarthy & Oliphant, 2013; Taylor et al., 2008; Taylor, 2008; Venkat & Adler, 2012) have shed some light on this question and raise a range of issues including teacher knowledge, language, opportunities to learn, teaching time, home resources and learner dispositions. Hoadley (2012) however, offers a classroom specific perspective of why the

[1]The SA Numeracy Chairs at Rhodes and Wits University are funded by national research funding organisations and focus on both research and development in primary mathematics in South Africa.

problem persists, listing features of South African primary schools classroom as places where:

- Oral discourse dominates with limited opportunities to read and write
- Classroom interaction patterns privilege the collective (chorusing)
- Limited feedback or evaluation of student responses takes place
- Most learners are learning in an additional language
- Learning is communalised rather than individualised (pp.198-199)

These factors point to an absence of the learner-centred practices, which are consistently promoted in the current CAPS documents and previous post-apartheid curriculum reforms. Thus we see a discrepancy between the intended and implemented curriculum and possible reasons why we continue to perform badly in international and national assessments.

Specifically with regards to mathematics issues, Setati (2005) argues that in many South African mathematics classrooms the discourse is primarily procedural and lends itself to low cognitive demand tasks. Hoadley (2012) concurs, pointing out that systemic tests and small scale research studies show that this low level of cognitive demand is exemplified for example by a dominance of concrete methods over abstract understanding, slow placing and lack of coherence in lessons (Askew, Venkat, & Mathews, 2012; Hoadley, 2012; Venkat & Adler, 2012). Ensor, Hoadley, Jacklin et al. (2009) argue that as a consequence

> *learners' opportunities to grasp the symbolic system of mathematics are inhibited by classroom practices that privilege concrete modes of representation, which restrict access to more abstract ways of working with number, and by the inefficient use of class time* (p. 8).

Schollar (2008) echoes this and indicates that results from his study show that

> *the majority of South African learners are not developing any kind of understanding of the base-10 number system and the associated critical understanding of place value. They cannot mentally, or in writing, manipulate numbers, especially when they are large or contain fractions, do not readily understand the meaning of multiplication and division and cannot use the skills of borrowing and carrying upon which all more complex calculations depend* (p.6).

From this brief look at some of the issues in South African education, learning mathematics at school is problematic for the majority of learners in South Africa. Learning is constrained in numerous ways including ineffective classroom practices and increased pressure of teaching learners for the systematic assessments rather than working to redress the learner gaps the majority of learners have from the previous grades.

Responses to the crisis

Many national and provincial programmes initially responded to this educational crisis by focusing on grade 12 teaching and learning but this has not had the desired effect on performance results (Eastern Cape Department of Education, 2011). Thus Taylor et al. (2008) point out that both national and provincial Departments of Education have begun to focus on the problem of *primary school* learning. Examples of programmes with a primary focus include the Eastern Cape Provincial Remedial Plan and Improvement Strategy which followed the 2011 ANA results, the Foundations for Learning Campaign mentioned earlier (2008) and the Eastern Cape learner attainment improvement strategy for 2013-2015 (Eastern Cape Department of Education, 2013).

Driven by these same imperatives, national research funding organisations have also begun to invest in research and development projects which address primary school teaching and learning. The Numeracy Chairs at Rhodes and Wits University are examples of this focus. The work of the South African Numeracy Chair (SANC) at Rhodes University has been conceptualised around two interconnected communities of practice in the broader Grahamstown, Eastern Cape area, those of research and development.

The objectives of this specific Chair are to improve the quality of teaching of in-service teachers at primary level and to improve learner performance in primary schools as a result of quality teaching and learning. In 2014 the Chair is in its fourth year and one significant area of research aims to understand what factors are key to learners becoming mathematically proficient. The SANC project also examines the effect that programme activities aimed directly at learners has on the development of proficiency and how these activities work to enable increased mathematical access, participation, enjoyment and creativity.

It is within this specific context of the implementation of learner-focused programmes, in the form of after school maths clubs, of the SANC project at Rhodes University, that my study is located. The second key development project of the SANC project is the teacher development programme, which is known as NICLE (Numeracy Inquiry Community of Leader Educators). This programme has two strands: regular teacher workshops held throughout the year and school visits in which members of the SANC project team focus on working together with the teachers in the classroom to find ways of strengthening numeracy learning.

My role in the SANC project and broader numeracy crisis

In 2011 I was attracted to work in the SANC project driven by a personal desire to return to teaching and work with learners as a way of contributing to the crisis situation. I therefore joined the SANC project as a part time PhD student researching after school maths clubs as conceptualised by Graven (2011a). In the latter half of 2011, Mellony Graven and myself piloted a maths club at a local Grahamstown school. In 2012, I joined the project full time as maths club co-ordinator, PhD fellow and member of the SANC project team. I was responsible for setting up and rolling out clubs in the project as well as running two clubs for my own research.

However, in 2013 following several presentations on our club work at various conferences, I became increasingly involved in teacher and facilitator development for clubs. Additionally we began using the learning from clubs to feed into the project’s teacher development programme (NICLE). Thus I am currently a fully participating member of the SANC project team involved in:

- Running and co-ordinating clubs and club workshops locally and provincially
- Planning and presenting in NICLE sessions and visiting schools with Mellony Graven for in-class teacher support
- Co-ordinating and maintaining the project website and social media as platforms for sharing and dissemination of resources to the local and broader communities
- Supporting the project’s research community (post graduate supervision and lecturing)

Given the above, when referring to joint work that I do with the Chair and SANC project team members, I use ‘we’. When referring to work that I have undertaken specifically for this PhD study, I refer to ‘I’. In the next section, I will define some key constructs for the study and then detail the purpose of this study.

1.2 PURPOSE OF THE STUDY

Before discussing the purpose of this study, I briefly offer some definitions so as to provide a backdrop for the understanding the purpose of the study and the research aims. The empirical field for this study is two after school maths clubs run within two SANC project schools. These clubs are conceptualised as informal learning spaces focused on developing a supportive learning community where learners can develop their mathematical proficiency, make sense of their mathematics and where they can engage and participate actively in mathematical activities. Individual, pair and small group interactions with mentors are the dominant practices with few whole class interactions. The clubs were intentionally designed to contrast some of the more formal aspects observed in the classrooms of the SANC project participating schools (Graven & Stott, 2012b; Graven, 2011a). Of note is that some of the intended practices promoted in the clubs are those learner-centred practices promoted in the official curriculum documents (Department of Basic Education, 2011a) and which Hoadley (2012) notes are absent in South African classrooms. Some of these contrasts are described in Table 1 below. More detail about the empirical field and club programme design is provided in Chapter Three.

Table 1: Contrasted classroom and club environments

Observed mathematics classroom environment[2]	Intended club environment
Compulsory attendance is expected as part of formal schooling (in-school-time)	Voluntary participation during out-of-school time
Less learner choice over the activities that they work on and engage with	More learner choice over the activities that they work on and engage with
Curriculum and assessment standards as a prescriptive framework strongly influencing choice of content and activities (i.e. the South African curriculum documents)	Curriculum as contextual guide for what is nationally expected of learners but individual learner numeracy levels guide content and activities
Largely acquisition based and often driven by teaching for/to assessments	Participation based. Participants are active and engaged
Teacher led and much whole class teacher learner interaction	Many interactions are learner led with few whole class-mentor interactions and many one-to-one interactions between mentors and learners.
Assessment tends to be summative and results in ranked performance (e.g. South African Annual National Assessments)	Assessment is formative and integrated and used to guide individual learning experiences for participants
Prescriptive, teacher controlled classroom rules within general school rules	Negotiated socio-mathematical norms[3] which may differ from in-school time rules

Source: Adapted from Graven, M., & Stott, D. (2012b)

[2] It is important to note that items on the left hand side are not considered negative but rather in line with school norms whilst much more freedom is available in the clubs.

[3] Cobb & Yackel (1996); Hunter (2008)

My research focus is twofold: firstly I focus on the development of mathematical proficiency in Grade 3 learners in after school maths clubs and secondly I focus on the nature of mediation in these clubs. The SANC project works with a definition of *mathematical proficiency* that is drawn from Askew, Brown, Rhodes, Johnson and William (1997) and Kilpatrick, Swafford and Findell (2001):

> *the ability to process, communicate and interpret numerical information in a variety of contexts (Askew et al., 1997) overlaid with strands of numeracy proficiency (Kilpatrick et al., 2001): understanding numeracy concepts, computing fluently (practically, mentally and procedurally), applying concepts to solve problems (in creative and inventive ways), reasoning logically (in creative and inventive ways) and engaging with mathematics – seeing it as sensible, useful and do-able (enjoyment and passion)* (Graven, 2011c)

Working from a Vygotskian perspective, *mediation* is defined as a form of intervention that focuses on experiences during the process of thinking and learning. It refers to use of cultural tools (or signs) to bring about qualitative changes in thinking. This notion is unpacked in Chapter Two.

The main purpose of this study therefore is to centre my attention on how Grade 3 learners' mathematical proficiency progresses (or not) whilst participating in after school maths clubs over the course of a year, thus aligning with one of the SANC project's key focus areas of intervention (Graven, 2011c). Additionally, I wish to explore the nature of the mediation provided in the maths clubs and how this enables or constrains the emergence of zones of proximal development (ZPD) in the club learners. Deeper understanding of this is important for both the SANC project's club work and the NICLE teacher development programme.

Thus it is hoped, that this in turn, may have practical implications for feeding back into facilitator development in the broader club programme and for the classroom-learning environment through the teacher development programme (NICLE) in our project. Through the duration of this research, the clubs have been used as mini explorative spaces (or 'labs') for those SANC project team members who both run clubs and work with teachers. The clubs provide the space where we can try out new activities and games, test theories, frameworks and assessments before sharing them with teachers in NICLE and with in-service teachers undertaking post-graduate mathematics courses (in which the SANC project is involved) at Rhodes University.

Working within an interpretive research paradigm, this longitudinal case study research aims to explore the mathematical proficiency of learners in two clubs and to examine the nature of the mediation evident in the clubs. Specifically the research questions are:

1. How do learners' mathematical proficiency levels evolve (if at all) over the period of participation in the maths club?
2. What is the nature of the mediation that enables or constrains the emergence of a ZPD in the club learners?

The two research questions additionally address a number of gaps in the literature and research. Kilpatrick et al.'s (2001) strands of mathematical proficiency are widely used in South African research and curriculum documents (see for example Department of Basic Education, 2009). However neither the CAPS tests nor the ANAs provide a locally available instrument for assessing Grade 3 learners' mathematical proficiency progress over time with regard to these strands. Therefore, in this study I aim to draw on work from the Maths Recovery programme one-to-one assessment interview (Wright, Martland, & Stafford, 2006; Wright, 2003) and from the oral instrument used in the widely cited Effective Teachers of Numeracy study (Askew et al., 1997) to address this need.

There is a significant amount of international research on learning in the ZPD. Meira and Lerman's (2001, 2009) work has moved understanding of this notion forward. This research aims to understand what their work might mean in a local context and specifically within after school clubs. In the same way, research on mediation and scaffolding proliferates in the international literature. However, this research does not take into account the extreme nature of the 'backlog' of learning in the South African context mentioned earlier. Again, this study aims to understand the extent to which the scaffolding and mediation notions prevalent in the literature might be different in a 'crisis' context of learners with extremely weak mathematical foundational knowledge.

Other purposes are to contribute to the body of research on after school learning programmes both locally and internationally and to understand what advantages such learning contexts hold.

1.3 SIGNIFICANCE OF THE RESEARCH

I believe that the results from this study are significant for a number of reasons. In general, there is a lack of mathematical educational research in South Africa, particularly at primary school level. In 2009, a study undertaken by Venkat, Adler and colleagues on South African research produced between 2000 and 2006 revealed that mathematics teaching and learning represents the ‘bread and butter’ of work in the field of mathematics education and is located particularly in the context of curriculum reform. However, the empirical base of the research tends towards secondary level education, with a “relative under-representation of empirical research at primary level” (Venkat et al. 2009, p.10). The two Numeracy Chairs at Rhodes and Wits have been tasked with developing the field of numeracy research in South Africa. As my work is located in the primary level, this is a good opportunity to contribute to this newly developing field of study and to the emerging maths research community that is being developed up by these two Numeracy Chairs.

Mathematical proficiency for every learner is a theme echoed around the globe (Kilpatrick et al., 2001; Kilpatrick, 2001) as the quote below reveals.

> *For people to participate fully in society, they must know basic mathematics. Citizens who cannot reason mathematically are cut off from whole realms of human endeavour. Innumeracy deprives them not only of opportunity but also of competence in everyday tasks (Kilpatrick, Swafford, & Findell, 2001, p. 1).*

Understanding better how mathematical proficiency develops in Grade 3 South African learners is an important contribution to the work of the SANC project and potentially to growing the field more broadly.

South Africa needs confident learners who feel they can do mathematics so that they are able to go on and study mathematics in their further education and, importantly, be able to use mathematics in their everyday lives. South African curriculum documents explicitly state this need (Department of Basic Education, 2011a) as does the Provincial Remedial Plan and Improvement Strategy (Eastern Cape Department of Education, 2011). As revealed from the TIMSS 2011 results (HSRC, 2011), South African learners are not confident about learning mathematics. The fundamental elements of sense making, productive disposition and confident participation in mathematics are clearly stated in documents written by Graven (2013a) when reporting on the aims of the SANC project.

These elements are a focus of my work with the learners in my clubs and are discussed in later chapters.

Finally, literature on primary school academically oriented clubs is relatively limited, particularly so in Africa. From my literature search across regionally accessible journals and conference proceedings it seems that peer reviewed literature on school maths clubs in South Africa is non-existent apart from Graven's (2011a) article, which argues for the potential of maths clubs. Similarly, in the wider international community, there is a small amount of work on after school programmes, many of which focus on secondary school.

Finally, this study aims to contribute theoretically and methodologically to various aspects of mathematics education research particularly with regard to the zone of proximal development, mediation and the Learning Framework in Number (LFIN) as part of the Maths Recovery programme (Wright, Martland, Stafford, & Stanger, 2006; Wright, 2003).

1.4 STRUCTURE OF THIS THESIS

In this final section, I outline how this thesis is organised. *Chapter Two* combines the literature review and frameworks (theoretical and conceptual) as the theoretical perspective and the literature are integrally connected. Presenting them in this way allows for richer engagement with both as they mutually inform each other.

Chapter Three gives a detailed description of the empirical field. In the first instance I explain the context in which the empirical field is situated and my role in that context. I detail the design framework as this is how the empirical field is formed and structured. Additionally, I use zone theory (Goos, Dole, & Makar, 2007a) as an explanatory tool to structure the description of each club that forms the empirical field for my study. Furthermore I share lessons learnt from a pilot club and how these influenced the empirical field and the broader research study.

In *Chapter Four*, I document how I designed this research study from a methodological perspective. In this chapter I situate the study in a broader research paradigm and examine and review coherence between the theoretical, conceptual, methodological and analytical frameworks of my study. I then address the design of the research in terms of its timeline, data collection methods and approach to analysis. Finally I deal with some methodological tensions and dilemmas that arose during the study, outline the ethical considerations and discuss validity issues.

In *Chapters Five and Six* I present the findings for each of my research questions respectively. Each chapter concludes with a discussion of the findings, drawing out the main insights, explains results and makes links between the research aims, findings and the literature.

In *Chapter Seven*, I bring the discussions from the previous two chapters together, summarise the major findings, present limitations and implications of the study and suggest directions for future research. I also discuss the theoretical and methodological contributions that I make to the field.

---- *END OF CHAPTER ONE*----

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CHAPTER 2 THEORETICAL AND CONCEPTUAL FRAMEWORK & LITERATURE REVIEW

2.1 INTRODUCTION AND CHAPTER OUTLINE

The purpose of this chapter is twofold: one is to situate this study in the broader educational and mathematical literature and the second is to unpack the key concepts and constructs used in the research and to identify the relationships between these. In discussing these two aspects, I also detail the theoretical perspectives underlying my work. I have chosen to structure this chapter in this way because the theoretical perspective and the literature are integrally connected and presenting them in this way will allow for richer engagement as they mutually inform each other.

This chapter is divided into five sections. The first section (**2.2**) explores the overarching *dual* nature of this study and lays the foundations for other parts of this and other chapters. The second section (**2.3**), *Theoretical Perspectives* will put forward my theoretical position in terms of meta-theory, knowledge and learning assumptions. I also elaborate on dilemmas faced in coming to choose the underlying theories for my study. In the third section (**2.4**), *Club Learning Spaces and Design* I discuss the literature pertaining to after school programmes and the frameworks for the design of these. Section **2.5**, *Research Question Constructs* unpacks the concepts inherent in the research questions, looking to the literature to define them and examines the issues and debates surrounding them. In the final section (**2.6**) I summarise and provide a synthesis of the particular constructs I work with in this study.

2.2 THE DUAL NATURE OF THIS STUDY: HAVING AND DOING

Sfard's[4] (1998) much-cited article on the two metaphors of learning identifies and describes the differences between two metaphors for learning. '*Learning as acquisition'* implies that learning is the acquisition of something that is then stored in the individual. Learning as acquisition theories can be regarded broadly as mentalist in their orientation, with the emphasis on the individual building up cognitive structures (Sfard, 1998). Key words in studies using acquisition frameworks are *knowledge, concept, conception, idea, notion, misconception, meaning, sense, schema, fact, representation, material, content*. Other key words that express the action of making these entities one's own are for example: *acquisition, construction, internalisation, appropriation, transmission, attainment, development, accumulation, grasp*.

In contrast, the '*learning as participation*' metaphor considers learning as a *process* of becoming a member of a certain community, which entails the "ability to communicate in the language of this community and act according to its particular norms" (Sfard, 1998, p. 6). Sfard argues that the terms that imply the existence of the permanent entities of acquisition and knowledge (as nouns) have been replaced with the verb "knowing," which indicates action and as such states have been replaced with activities - "the permanence of having gives way to the constant flux of doing" (Sfard, 1998, p. 6). She points out that the on-going learning activities are never considered separately from the context within which they take place and that a new set of key words symbolise the participation metaphor such as *doing, practice, discourse and communication.* These suggest that the learner is viewed as a person "interested in participation in certain kinds of activities rather than in accumulating private possessions" (p.6).

While some educators argue for the need for a paradigm shift away from (or even rejection of) acquisition perspectives in favour of participation, Sfard put forward the argument that these metaphors are not alternatives but that each provides different insights into the nature of learning. She argues:

[4] It should be noted that more recently, Sfard has developed a theory of learning with an emphasis on discourse where learning and development are seen as changes in discourse. See for example her work entitled "Introduction to thinking as communication" (2008).

> *An adequate combination of the acquisition and participation metaphors would bring to the fore the advantages of each of them, while keeping their respective drawbacks at bay. Conversely, giving full exclusivity to one conceptual framework would be hazardous (Sfard, 1998, p. 11).*

In this study, I have purposely worked with both these metaphors using a complementary approach to the notions of acquisition and participation by drawing on Sfard's 'metaphorical mappings' (1998, p.7). Her table of metaphorical mappings (Figure 1 below) gives a tabular comparison of the two metaphors as she sees them. In later work, Sfard (2001) draws our attention to the idea that the participationist researcher will focus on the growth of mutual understanding and coordination between the learner and the rest of the community and the focus will turn to the activity itself and to its changing, interactional aspects. This is an important consideration for this study, as I will be exploring how learners' mathematical proficiencies evolve in relation to their participation in maths clubs and the nature of the interactions with a focus on mediation, in the context of mathematical club activities.

Figure 1: Sfard's (1998 p.7) Metaphorical mappings

Acquisition metaphor		Participation metaphor
Individual enrichment	Goal of learning	Community building
Acquisition of something	Learning	Becoming a participant
Recipient (consumer), (re-)constructor	Student	Peripheral participant, apprentice
Provider, facilitator, mediator	Teacher	Expert participant, preserver of practice/discourse
Property, possession, commodity (individual, public)	Knowledge, concept	Aspect of practice/discourse/activity
Having, possessing	Knowing	Belonging, participating, communicating

Often these two metaphors can be seen as being in opposition to each other. However, working within the broad sociocultural paradigm I describe in this chapter, the tensions between the two notions of acquisition and participation are nothing unusual. In this study I see the two notions as forming a yin/yang type of fit, which complement rather than conflict with each other. This is elaborated when I discuss Vygotsky's work in detail in section 2.3 below.

This complementary approach is a key part of this PhD study and is reflected and interwoven into all aspects of it. The two main research questions reflect the complementarity between the perspectives of acquisition (primary perspective foregrounded for question one) and participation (primary perspective foregrounded for question two) and as a result, so then do the findings, analysis and discussion of these questions in subsequent chapters. The discussion in section 2.3 below delves into this from a theoretical perspective whilst the section on club design brings to light how these metaphors are accommodated within the design of club activities (section 2.4 below). Similarly, the Methodology chapter will address these metaphors again in terms of how instruments that are used to collect the data for the study. The complementary nature of each of these relationships is shown in each relevant section using an adapted diagram of Sfard's metaphorical mappings (1998) indicating my interpretation for each aspect of my study. A summary of these diagrams across the chapters of the study is presented in Appendix A.

2.3 THEORETICAL PERSPECTIVES: META-THEORY, KNOWLEDGE AND LEARNING

One's view of reality (ontology), theory of knowledge and how one acquires knowledge (epistemology) informs what one wants to research and how one does this. Ontology is the "consideration of being: what is, what exists, what it means for something - or somebody - to be" (Packer & Goicoechea, 2000, p. 227). From an ontological perspective, this study views reality as socially constructed. This means that reality can be seen by multiple people who interpret events from differing perspectives, giving multiple perceptions of those events. Packer and Goicoechea (2000) argued that the sociocultural perspective supports a "nondualist ontology" (p. 239). They argue that this "ontology envisions a practical process of construction where people shape the social world, and in doing so are themselves transformed" (p. 234). In this study, I maintain a nondualist ontological stance, which coheres with the broad sociocultural perspective in which I am working.

This stance corresponds with an epistemological view that knowledge is gained through personal or collective experience giving a subjective meaning to knowledge. More specifically, the underlying foundation for this study is that knowledge is generated through collective activity, negotiation and meaning making as opposed to being generated on a personal basis in the individual mind or received from a pre-determined source. In this regard I prefer to use the term 'knowing' as Sfard (1998) suggests. Knowing emphasises the *process* of coming to know something, rather than the acquisition of a product or a predetermined body of knowledge (Askew, 2012a).

In terms of learning, Packer & Goicoechea described learning in terms of "changes in knowing" which involves broader changes in being. Thus learning is an "integral part of the broader ontological changes that stem from participation in a community" (2000, p. 227). In the sections that follow I expand upon these broader ideas and present the view of learning adopted for this study.

2.3.1 VIEW OF LEARNING

Lerman (2014) tells us that research in the field of mathematics education calls for

> *a study of the options, in terms of what learning and knowing are. Careful elaboration of how we might recognise learning and knowing according to the view we have adopted and some decisions regarding what information we will need in order to be able to call it evidence of learning and knowing* (p. 16).

Lerman (2014) goes on to point out that as researchers we need to be *reflective* and *reflexive* about our chosen theories and how they are used in our research precisely because we have multiple options in mathematics education. Radford (2008b) explains that theories of teaching and learning differ from each other mainly in their conceptions about the content to be learned, the learner and how learning actually occurs.

In this section I elaborate on conceptions of learning, how it occurs and how we might recognise it for the purposes of this study. In the Methodology chapter, I elaborate on the type of indicators I will consider as evidence of learning.

2.3.2 DILEMMAS OF SELECTING FRAMEWORKS

Before I describe my perspective on learning, I share my story of how I arrived at the particular view of learning presented here since this led to my choice of frameworks. Intense reflection has taken place, as this has been an area of confusion for me and a journey of struggle and growth. The initial conceptual framework in my research proposal was influenced by the framing concepts of the SANC project found in the documents written by Graven (2011c, 2010) for the SANC proposal; the original conceptualisation of the Maths Clubs (my chosen empirical field) by Graven (2011a); and by my proposed research questions. As such, the clubs were initially conceptualised as Communities of Practice/Inquiry and my view of learning was that of situated learning. The key framing concepts originally were: participating in a community of practice and inquiry (Graven, 2002a; Jaworski, 2007; Wenger, 1998), and learning as becoming (Wenger, 1998).

However, during the 2011 pilot of a maths club, my experiences in the club resulted in refinement of my research questions. This in turn pointed me to other frameworks that would allow me to answer my questions. As I carried out data analysis on an on-going basis, the pilot data pointed me in a different direction to the one originally planned.

Reading that theory needs to be "grounded in the data" (Lincoln and Guba cited in Cohen, Manion and Morrison 2000, p.150) and should emerge from it, resonated for me in this situation and I thus took a grounded approach to selecting the conceptual and theoretical framework for my study.

Some concerns arose when I considered my refined research questions. Research question one, focused on change over time in individual learners. Question two focused on the nature of the mediation that enabled or constrained the changes in learners when participating in the club community. If I was to work with a situated learning perspective, I found there to be a tension between my two research questions. Where does the learning reside after participating in the maths club in order for me to assess individual learners' mathematical proficiency progress?

I realised that I was simultaneously looking at the clubs from both an acquisition and participation viewpoint: one that is individual and developmental and another that is embedded in a social context and based around interactions between participants. On the surface, my questions were not necessarily rooted in the same theoretical perspective. For assistance with my tension, I turned to other authors who have wrestled with the same issue. Research indicates that struggles over combining these aspects was by no means unique to myself and has been discussed and debated since at least 1995 in mathematics education (see for example Cobb & Yackel, 1996; Confrey, 1995; Simon, 2009). Many researchers in mathematics education have described how they reconciled this tension in their own work. Below I illustrate how several researchers have overcome similar obstacles as this literature informs the way in which I proceeded with my research.

Lerman (2000) argues that in the mid 1980's a '*social turn*' in mathematics education research took place. Previous to this both Behaviourism and Piagetian psychology provided the theoretical frameworks for the majority of mathematics education research projects. This social turn was borne out of a number of factors such as the accessibility of Vygotsky's writing to the mainstream mathematics education community in the west. Additionally mathematics education research began to draw on work from anthropology, sociology and cultural psychology. This increased social focus allowed mathematics researchers to see "meaning, thinking and reasoning as products of social activity" (Lerman, 2000 p.23) and to consider the 'person-acting-in-social-practice' as the unit of analysis for the first time.

However, along with this expansion and choice, came a warning that analysis "should not reduce individual functioning to social and cultural determinism nor place the source of meaning making in the individual" (Lerman, 2000, p. 36). Lerman (1998) spoke of research as a zoom lens as a way of addressing this issue and stressed that "research must find a way to take account of the other elements which come into focus throughout the zoom, wherever one chooses to stop" (Lerman, 1998, p. 67) thus emphasising the importance of looking at all dimensions and not just fragments of the research situation. This 'gaze' "is as much aware of what is not being looked at, as of what is" (p. 67).

When new ideas emerge in a community, so do the tensions between the established ideas and the new ideas and hence the conflicts between the more cognitive / Piagetian approaches and the social approaches began to emerge in the mathematics education literature. For example, Confrey (1995) wrote an article entitled "*How compatible are radical constructivism, social-cultural approaches and social constructivism?*". Confrey was looking for an integrated theory of learning and development that allowed for participation in mathematics and her chapter put forward a number of characteristics for a possible 'alternate' theory.

Cobb and Yackel (1996) began to talk of an '*emergent*' perspective which provided a coordination of constructivist and social analyses by making use of more than one theoretical perspective in a single research situation thereby recognising the individual and social aspects raised by Confrey. Similarly, as discussed previously, Sfard (1998, 2001) highlighted these differences with what she calls the '*acquisition*' and '*participation*' metaphors. As she pointed out, each metaphor has its own relative advantages and that each has something to offer that the other cannot provide. She encouraged us to consider using more than one metaphor for analysis and explanation purposes.

What is evident from work published from 2000 onwards is a call for a more *pragmatic* approach (see for example Simon, 2009). A pragmatic approach seeks to use theories as *lenses* and not as strict frameworks to explain different situations and to gain a more complete picture of a research problem. The mutual benefits of different theories and the way they connect is foregrounded in a pragmatic approach. Rather than searching for a completely integrated / unified theory, researchers are using theories as a set of tools from which they can choose to address a particular problem.

Simon (2009) also uses the metaphor of the lens in a different guise. He advocates using *theories* as different lenses to look at research problems. He argues that multiple, but complementary theoretical frameworks or explanatory theories can provide a richer set of constructs with which to work. These pragmatic approaches resonated with my research. If, as Smidt (2009) points out, I took the view that neither one perspective is "true" and the other "false" (p. 13), then I could look for the connections between the constructs, to see how each contributes to a shared understanding of the whole and therefore see value in using both viewpoints. This is the approach that I have therefore chosen to take for this study.

When looking for a theory for one's work, Simon (2009) urges us to consider the fine distinction between what one looks at the study *with* (for example a social or cognitive perspective) and what one is looking *at* (for example, an individual learner, a classroom, a lesson, a curriculum). Like the lens of a video camera, on the one hand a theory can direct "attention towards particular settings, situations, roles, relationships, actions and objects" and on the other can "discard or ignore other features" (p. 483). In other words, at different points the lens can foreground certain aspects whilst backgrounding others. This happens frequently in this study as I move between the two research questions, one of which foregrounds the individual learner and the other which foregrounds the interactions between club participants and myself as club facilitator (or mentor).

Thus returning to the initial concerns I raised in the opening paragraphs of this section, I realised from my reading of the above literature that my study could benefit from complementary theories as lenses to help answer the two research questions. As suggested by both Radford (2008b) and Sfard (1998), by looking at the connections between theories rather than the disparities, I could benefit from the different insights that each offer to my study. As a result this has enabled this study to contribute a richer and deeper picture of my overall research aim of how learners' mathematical proficiency levels evolve in relation to their participation in after school maths clubs.

Having resolved the tension from a theoretical point of view, I subsequently grappled with various learning theories and chose Vygotsky's (1978) view of learning and development[5]

[5] I initially planned to use a social constructivist theory of learning for research question one and a socio-cultural one based on Vygotsky's work for question two. However, in consultation with Prof Steve Lerman[5] on my theoretical framework and the tensions I was faced with, he pointed out that there is not really a tension between my questions as

for my study. Many of my constructs are directly related to his work. This view is discussed in the next section.

2.3.3 VYGOTSKY'S THEORETICAL AND CONCEPTUAL FRAMEWORK

It is important to unpack the context in which Vygotsky worked and the issues this raises for researchers and educators because I use multiple aspects of his work across the chapters of this thesis (see Table 4 in the Methodology Chapter). Portraying Vygotsky's rich and complex work without being superficial or trivial is a challenge but critical in terms of outlining my views and use of his work for this study. I thus detail his view of learning and development, the constructs that are needed to discuss this and indicate how these are relevant to my study.

Contextualising Vygotsky

Vygotsky, during his short life, drew on the ideas of Marx, Engels, Hegel, Durkheim, Spinoza, Janet and Gestalt psychologists as well as critiquing the work of his contemporaries such as Piaget and Pavlov (Davydov, 1995). These ideas had a profound influence on the development of his own ideas and resulted in work that was, and is still both rich and complex. The majority of his work was produced in the 10 years preceding his death in 1934, during which time he lectured and wrote on the problems of education (Cole & Scribner, 1978). However, when Stalin came to power, his "leadership in restructuring psychology, education and culture" (Holzman, 1999) in what he hoped would be a new kind of society, came to a halt. Two years after his death in 1936, his work, discussion and dissemination of it was banned, although a small group of his students and followers managed to keep his writings intact (Cole & Scribner, 1978; Davydov, 1995; Holzman, 1997; Smagorinsky, 2009).

Over the last 30 years or more as Vygotsky's (for example 1978, 1987) work has become more readily accessible to researchers in the West, his ideas have become increasingly taken up by researchers and educators and interpreted in a variety of ways. As Bernstein eloquently puts it: "in a way we have caught up with Vygotsky. It's not so much an idea finding the time, but a time selecting its idea" (Bernstein cited in Daniels, 2001, p. xviii).

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both social constructivism and Vygotsky's view of learning take into account the individual and the social context of learning.

Vygotsky provided key concepts that are now regarded as important contributions to the development of a contemporary social theory; a theory that acknowledges the features of cognition situated in particular contexts and distributed across the individuals acting in those settings (Daniels, 2008). For example, socio-cultural, cultural-historical theory and activity theory, distributed cognition and situated cognition are all closely linked to his work and his key concepts (Daniels, Cole, & Wertsch, 2007b; Daniels, 2008). In this study, as stated previously, I work in a broad socio-cultural context but not with any of these specific theories.

Many disciplines cite Vygotsky with regard to learning and development but many authors are concerned that these references are ill informed (see for example Chaiklin, 2003; Daniels, 2008; Smagorinsky, 2009). This is due in part to the problems of language and translation from Vygotsky's original texts (which were rich and complex and written in Russian) and hence, many researchers are guilty of what Smagorinsky (2009) calls "trivial applications" (p.86) and superficial referencing of Vygotsky's work. He cites examples

> *I have come across the ZPD in accounts of teaching and learning without attention to their cultural and historical dimensions—a central feature of a ZPD analysis. I have also seen Vygotsky's concern for the importance of "play" stretched to imply that Vygotsky believed that learning should be 'fun'" (Smagorinsky, 2009, p. 86).*

Gredler (2012 p. 113) argues that the taking up of Vygotsky's ideas have been hindered by four factors: an inaccurate portrayal of a 'minor' idea (the ZPD) in *Mind in Society*, the unavailability of accurate translations of his complete theory for many years, Vygotsky's own definitions for some terms and there being little known about his emphasis on scientific concepts.

The challenge posed for me in this research was how to portray and use Vygotsky's rich and complex work in an appropriate manner. I use multiple aspects of his work in this thesis (as summarised in Table 4 in the Methodology Chapter). Accordingly, I historically locate his work below. Looking at Vygotsky's context, I note "two different historical eras", a world war and "multiple social milieus": those of Russia, the Russian Revolution, the Soviet Union and other parts of the world in the early decades of the 21st century (Daniels, Cole, & Wertsch, 2007a, p. 4). Smagorinsky (2009) indicates that Vygotsky was a product of his times, but he also helped to shape his times and it is this sense of “situated agency” that is critical to understanding a Vygotskian perspective (p. 87). Many authors argue for taking account of this “reciprocal conception of context” (Smagorinsky, 2009, p. 87), as it can produce insights into Vygotsky’s thinking and how the setting of his life and work contributed to the trajectory his ideas took. At the same time, in using his work for my own theoretical and conceptual perspectives, I have no expectation of arriving at a “single truth about the man” or his ideas as these continue to be researched and reflected upon (Daniels et al., 2007, p. 4). In this respect Bernstein talks of Vygotsky being a catalyst for other perspectives, rather than providing us with a fully worked-out theory:

> *His perspective can be linked with others because of his orientation and total project. Vygotsky here is more of a catalyst than a provider of a worked-out theory, which it is obviously not, nor has it ever pretended to be. In his short life, Vygotsky used broad brush strokes to outline new images (Bernstein cited in Daniels, 2001, p. xxiii).*

With these insights in mind, I unpack some key concepts that allow me to research how children learn and develop from the Vygotskian perspective. For the purposes of my study, I review the notions of development and learning, internalisation, everyday and scientific concepts, the zone of proximal development and mediation. Steele (2001) outlines a broad picture of Vygotsky’s perspective from a mathematical point of view:

> *For Vygotsky, individuals come to learn the meanings of a culture by internalising the meanings and being transformed by them as they learn to speak the language of the culture. Thus, students … develop mathematical meanings as they learn to explain and justify their thinking to others. As they learn to speak the mathematical language, they transform their thinking of the mathematical concepts. The mathematical language comes from society, and thought (concept) comes from the individual (Steele, 2001, pp. 404–5).*

The quote interprets the way that Vygotsky saw the connection between society and the mind. Vygotsky and a number of other theorists (see for example Ernest, 2003; Sfard, 2008), argue that thought itself is internalised conversation. He claimed that thought is constituted and formed by intrapersonal (within oneself) conversation, and that thinking is internalised conversation with an imagined other. Smidt (2009) cites Wells (1986) in illuminating this. Children try to make sense of their world, mostly through making, using and interpreting signs (p. 52). Signs take many forms: words, images, sounds, acts and objects. Until a sign is invested with meaning or it signifies something, it has no "intrinsic meaning" (p. 52) to the child. People who educate young children are "responsible for inducting them into a world made up of symbols" (p. 53). Children, through their interactions with the social world, acquire signs or symbols, which are useful to them. They in turn use these signs themselves to interact with others and to explain. Dyson (cited in Smidt, 2009) says that the gap between the child and the more expert other in terms of understanding the signs they have appropriated becomes an "interactive space" (p. 54) where common meanings and signs are negotiated. This interactive space is critical to this study as the clubs are the interactive space in which learners come to negotiate and understand the signs of the mathematical world.

In the next section I elaborate on Vygotsky's view of development and learning as used for this study.

Development and Learning

According to John-Steiner[6] and Mahn (1996) Vygotsky conceptualised development as the transformation of socially shared activities into internalised processes. Vygotsky (1978) stated that one of the essential aspects of development is the "increasing ability of children to control and direct their own behaviour" (p.126). This is made possible by the development of new mental processes and by the use of signs and tools in the process of development side by side with collaboration or assistance from others. Davydov (1995) argued that Vygotsky emphasised the activity of *all* participants in the learning and development process: "the child, the child's social milieu, and the teacher" (p. 17).

Holzman (1997) argued that "to Vygotsky, learning / instruction and development are a dialectical unity in which learning *leads* development" (p. 57; own emphasis). This unity of learning/instruction-leading-development develops as a whole. Learning cannot exist without development and development cannot exist without learning (p. 58).

There seems to be conflicting views in educational literature about the interpretation of the word '*leads*' in Vygotsky's work. In common English language usage the word denotes

[6] John-Steiner, along with Cole and others, edited Vygotsky's Mind in Society (1978)

‘coming before’ or ‘causing’. This is a common interpretation of what Vygotsky meant in that learning precedes and or causes development. He himself stated that good learning is in advance of development (1978, p.89). Holzman (1997) however believed that this is “misguided” (p.58). She asserted that as a dialectical unit, development and learning are inseparable. Therefore learning is connected to and leads development dialectically but not chronologically or in a linear fashion. Vygotsky (1978) also stated that even though learning is directly related to development they are “never accomplished in equal measure or in parallel” (p. 91). He also said that development never shadows school learning and that in reality the dynamic relations between learning and development are highly complex.

Levykh (2008) argued that this dialectical approach “stands in opposition to the mainstream Western educational views that are mainly grounded in somewhat ‘linear’ Piagetian thinking” (p. 89). In other words, the process of development is not a direct and natural process, but rather indirect, artificial, mediated (governed) by cultural laws of teaching-learning and “in contrast to Piaget proceeds not toward socialisation, but toward converting social relations into mental functions” (Levykh, 2008, p. 89). Vygotsky described the dialectical nature of learning and development thus

> *learning awakens a variety of internal-development processes that are able to operate only when the child is interacting with people in his environment and in cooperation with his peers. ... learning is not development; however, properly organised learning results in mental development and sets in motion a variety of developmental processes that would be impossible apart from learning. Thus learning is a necessary and universal aspect of the process of developing culturally organised, specifically human, psychological functions* (Vygotsky, 1978, p. 90).

The aspects of learning and development from the above that are key for this study are that learning leads development. Learning cannot exist without development and development cannot exist without learning. The “process of development is indirect and mediated by cultural laws of teaching-learning” (Levykh, 2008, p. 89) since learning and development are interlinked in this way for this study. As a researcher I needed to investigate *how* the learners in my study interacted with people in their environment and *how* mediation took place to encourage learning.

Vygotsky (1978) himself indicated that each school subject has its "own relation to the course of child development, a relation that varies as that child goes from one stage to another" (p. 91) and encouraged extensive and concrete research on the ZPD to resolve the issues related to each discipline. This is of importance to this study because I use a framework (the Learning Framework in Number (LFIN) discussed in section 2.5 below) that defines mathematical learning pathways to determine learner mathematical proficiency progress which consists of stages of mathematical development. This framework (and a related interview instrument, discussed in Chapter 4) is used to determine club learners' actual levels of development and using the stages in the framework, to determine where to focus activities that will promote learners' emerging mathematical functions and capabilities.

Internalisation

Vygotsky (1978) emphasised the role of semiotic (systems of signs and symbols) mediation, in effecting the internalisation of activity. It is through mediation that a child is able to transform external activity into internal activity and therefore understanding. The child learns and develops concepts through internalisation, transferring from the social (interactional) plane to the individual (internal) plane. Following his emphasis on the central place of instruction at the heart of cognitive development, Vygotsky emphasised the central role of the teacher or mediator in 'leading' development. "It is in the zone of proximal development that this 'leading' or 'mediation' is enabled to take place through collaborative activity" (Daniels, 2001, p. 156).

Vygotsky's (1978) approach to development by means of mediation through tools and signs is based on the concept of internalisation - the only process that allows lower mental functions (everyday functions) to be developed into higher mental functions (Levykh, 2008). Vygotsky argued that the process of internalisation lies at the root of cultural development and represents the "powerful urge individuals feel to interiorise or appropriate certain elements of social behaviour. He called this process a 'revolution' because, according to him, there must be some extreme change within the child that prompts him or her to appropriate what was once social" (Levykh, 2008, pp. 94–95).

The process of internalisation is not a simple transfer of the functions inward, but rather "a complex reconstruction of its whole structure" (Levykh, 2008, p. 95). If the ZPD represents those processes that are in the course of maturing or are about to be developed, then internalisation marks the point at which these processes become part of the developmental achievement of the child. Smidt (2009) stated that once internalised, the child can deal with concepts without having an object or situation to refer to. She also stated that internalisation occurs in the "context of social interaction" (p. 28) and in terms of the semiotic systems, which mediate those social interactions.

Through mediation and the use of cultural tools (both explored further below), the child can move from being dependent on others and on concrete everyday experiences to being able to remember, internalise and use those experiences independently. This is the path by which everyday mental functions become higher mental functions. Smidt (2009) stated that these higher mental functions are conscious and include "verbal thinking, logical reasoning and selective attention" (p. 27).

Chang-Wells and Wells (1993 cited in John-Steiner & Mahn, 1996) pointed out that a distinctive characteristic of Vygotsky's internalisation is the "*creation* of a new plane within the individual" rather than the *transfer* of the social plane onto an individual plane. In other words internalisation is the *process* in which the individual plane is formed. More specifically, it is at the point where negotiation of meaning occurs in conversation that learning and development take place.

It is through mediated, social, collaborative activity that these higher mental functions are reached. Therefore development cannot be separated from its social and cultural context and so in order to explore the development of mental processes as a researcher I must understand the social interaction and tools that mediate them, in other words mediation. This is an important aspect of this discussion as it links directly to *both* of my research questions since I am seeking to understand the progression of learners' mathematical proficiency and the nature of mediation within the clubs that might enable or restrict this progression. In order to investigate how that happens I need to research the nature of the social interactions in the clubs and the tools that have mediated that social activity.

Concept Development

Vygotsky (1978) argued that the concepts (or understanding) children form are not fixed but evolve or develop over time, just as the meaning of signs develops over time (see the section on Mediation below). He spoke about two types of concepts: spontaneous (also known as everyday) concepts and scientific concepts.

Spontaneous concepts are those acquired by the child *outside* of contexts in which explicit instruction takes place and are a product of the child’s immediate experience (Daniels, 2007, p. 311). These are the concepts that the child encounters through interactions with others and activity in the everyday worlds of home and community through “first-hand experience” (Smidt, 2009, p.66), thereby learning about those concepts that relate to their daily lives. Spontaneous concepts are learned through cultural practice and, because they are tied to learning in specific contexts, allow for limited generalisation to new situations. The strength of these concepts is that they have arisen from direct experience. Smidt (2009, p. 66) cited examples of cooking, sickness, eating, the birth of siblings, travelling and so on.

Scientific concepts are those that are introduced or which arise through some type of systematic or planned instruction such as that in formal school teaching. These concepts are decontextualised and are normally part of a formal system of knowledge, forming a coherent, logical hierarchical system. Scientific concepts learned through formal instruction are grounded in general principles and can more readily be applied to new situations.

Smagorinsky, Cook and Johnson (2003) argue that scientific concepts require “interplay with spontaneous concepts” (p. 1399). In other words they develop by building upon everyday concepts which can be developed without formal instruction. Goos (2004) concurs calling this interplay ‘interweaving’. She states “mature knowledge is achieved with the merging of everyday and scientific concepts, not by replacing the former with the latter […] but by interweaving the two conceptual forms” (p. 263). Fleer and Ridgway (2007) argue that when everyday concepts and scientific concepts are interlaced, a child’s “thinking and practice will be transformed” (Fleer & Ridgway, 2007, p. 26).

It is through the social processes of collaboration and interaction, that a child’s everyday representations can be brought together, interwoven or interlaced with the more abstract scientific representations. Hedegaard (2005) suggested that this can be done if the educator keeps the everyday concepts and scientific concepts in mind when planning for learning, calling this a “double move” (p. 232) in teaching. Knowing how the two concepts can be ‘interlaced’ within a teaching and learning context is “important for building pedagogical approaches for early childhood education” (Fleer & Ridgway, 2007, p. 26).

The above is important to this study because developing the concepts of number, number sense and basic number facts in learners can be seen as developing both everyday and scientific concepts. Some believe that teaching the number bonds to twenty for example would be better approached as developing scientific concepts, i.e. developing and teaching them in a systematic way (see Askew, 2013 for example).

Mediation was Vygotsky's key contribution to understanding child development and is a focal aspect of this study as it enabled me to investigate the nature of mediation that enabled or constrained the emergence of a ZPD in club learners for research question two. In the next section I explore this concept from a Vygotskian perspective and provide a review of the literature on mediation that I draw on for this study.

Mediation

In order to understand mediation, it is necessary to define Vygotsky's use of the term *tools*. Vygotsky differentiated between *physical* and *psychological* tools in that physical (external or material) tools are directed towards being used in the external world whilst psychological (internal or mental) tools are directed internally and are appropriated during activity. These psychological tools can also be referred to as *cultural tools*. Smidt (2009) defined cultural tools as "devices humans use for mastering their thinking and problem-solving" (p. 33). Vygotsky (1978) defined cultural tools as language, systems of counting, mnemonic devices, symbols (including algebraic and musical symbols), works of art, writing, diagrams, maps, road signs etc. For Vygotsky, the primary cultural tool was language.

To say that learning is mediated means that something acts as a facilitator to learning, something moves between the learner and the concept to be learned. Lerman explained it thus:

> *Vygotsky argued that the response to any stimulus is always mediated or interpreted, it is explained, and its use is elaborated: by a parent, by a sibling, by a peer, by a text and, of course, by teachers. […] Thus mediation is Vygotsky's way of breaking the direction of the response to a stimulus. The response is mediated: stimulus → mediation → response* (Lerman, 2014 p. 18).

Similarly, Levykh (2008) indicated that successful learning is never direct but rather is always mediated by cultural and psychological tools. These tools help human beings master the natural world around them and, in doing so, master themselves. Wertsch's (2007) view corresponds with Levykh's (2008).

> *Instead of acting in a direct, unmediated way in the social and physical world, our contact with the world is indirect or mediated by signs. This means that understanding the emergence and the definition of higher mental processes must be grounded in the notion of mediation (p.178).*

The view of mediation adopted for this study is as a form of intervention that focuses on experiences during the process of thinking and learning. It refers to use of cultural tools (or signs) to bring about qualitative changes in thinking.

The Zone of Proximal Development

In this study, the ZPD is a central notion that I use as an analytic tool for examining the mediational process (research question two). In this section I explain briefly Vygotsky's definition of the ZPD and then review how it has been subsequently interpreted in mathematics education research literature. In Chapter Three, I explain how the notion of the ZPD arose for this study within the piloting phase of the first club and detail for my specific research how and why the ZPD provides the key construct for addressing research question two.

Vygotsky's definition of the ZPD

Vygotsky's ZPD construct arose relatively late in his career and he first spoke about this at a conference in 1933, a year before he died (Meira & Lerman, 2001). Thus, Vygotsky himself was sometimes vague about the construct, as it was not fully formed in his own mind (Daniels, 2001, p. 111). According to Chaiklin (2003), Vygotsky wrote briefly about the construct in many texts but there is not an "extensive corpus of material from which Vygotsky's true meaning, or official definition or interpretation can be found" (p. 4).

Smagorinsky (2009) argued that the ZPD is probably Vygotsky's best-known concept in the West but that it is often construed as an "ahistorical instructional dyad" (p. 90) between a child and a more knowledgeable other, usually an adult. For those familiar with the idea of the ZPD, it may appear a simple notion. This is not the case if it is read in the variety of contexts in which Vygotsky described it (Smagorinsky, 2007). One widely quoted definition of the ZPD appears in Vygotsky's 1978 work:

> *it is the distance between the actual development level as determined by independent problem solving and the level of potential development as*

> *determined through problem solving under adult guidance or in collaboration with more capable peers* (Vygotsky, 1978 p. 86).

Many researchers (Daniels, 2008; Smagorinsky, 2009; Van Oers & Duijkers, 2012) regard this version of his description of the ZPD as problematic as it can be interpreted to legitimise transmission types of teaching. These authors stress that it is important to view the ZPD in the broader context of Vygotsky's developmental theory and from the variety of viewpoints that he put forward.

The definition above was by no means the only way that Vygotsky himself described the ZPD. Vygotsky mentions the ZPD in connection with his work on both assessment and instruction (1978). It was also integrated into his theory of play (Daniels, 2008; Meira & Lerman, 2001). The ZPD and the particular definition above arose primarily because of the conceptual problems Vygotsky was trying to address at different periods in his work (Chaiklin, 2003).

A close reading of these variations of the ZPD shows that the ZPD is *not* Vygotsky's theory of development, but a mechanism for explaining the *process of how* learning and development *take place* in different scenarios. Indeed, this is how I use it in this study.

Drawing directly on his writings (Vygotsky, 1978, 1987), I unpack the actual term 'zone of proximal development'. The key word in the ZPD is *proximal*, meaning 'coming next'. This supposes a notion of what can *potentially* happen. What the child does independently when involved in a task reveals what that child knows and can do today without assistance; the development that has already taken place or "completed development cycles" (Vygotsky, 1978 p. 85). *Potential* (or proximal) refers then to "those functions that have not yet matured but are in the process to maturation" (Vygotsky, 1978 p. 86) and thus what the child may be able to do with help or through interaction with others. Vygotsky (1978) proposed, "an essential feature of learning is that it creates the zone of proximal development" (p. 90). Note that this notion of learning creating a ZPD contrasts with some of the conceptualisations of the ZPD presented later in this section.

Learning and thus the creation of a ZPD involves initial collaborative activity or mediated learning. This mediated process is "future oriented" (Levykh, 2008 p. 90) in that it aims to develop those mental or psychological functions that are in the process of maturing or about to mature. Vygotsky described this mediated process as follows:

> *what the child is able to do in collaboration today, he will be able to do independently tomorrow* (1987, p. 206).

Vygotsky's ZPD is therefore seen as a cultural process of assistance through cooperation and collaboration. Vygotsky found it important to explore the *nature* of learning in the ZPD and *how* the child responded to the mediation or assistance offered. This too is of importance to this study, as research question two addresses how learners respond to mediation offered. As noted, the process of learning in the ZPD is mediated by the use of psychological tools (or cultural tools) such as language, systems of counting, and so on. For Vygotsky, language is the primary cultural tool, with speech being the primary mediational means. This has implications for my study in terms of what to examine when gathering data and zooming in during the analysis process.

I now turn to examine how educators and researchers have interpreted the ZPD construct. Many have tried to operationalise it in different ways since Vygotsky's death and as more of his work has become accessible in the West. Work continues to be published on the ZPD in education and specifically mathematics education (see for example Levykh, 2008; Meira & Lerman, 2009; Norton & D'Ambrosio, 2008; Radford, 2010a; Roth & Radford, 2010).

Chaiklin's (2003) article discussed many issues and interpretations of this concept and he argued that even though there is "slender textual material available from Vygotsky about the zone of proximal development" (p.15), the diversity of interpretations has been sufficient to encourage much research. Chaiklin (2003) maintained that due to the "underspecified nature of the original formulation and the variety of practical situations in which the idea is being used" (p. 15), this research is likely to continue and indeed is necessary to refine our understanding of this notion. He also stated that many new developments dilute the theoretical issues rather than deepen them.

ZPD Interpretations in Education:
(with a particular focus on mathematics education research)

The usefulness of the ZPD in terms of its implications for teaching could be one reason why is has been the subject of considerable research and pedagogic use across educational disciplines including mathematics education. However, Daniels (2008) suggests that its popularity could be attributable to its "perceived malleability" (p. 25), adding that reading of educational literature might leave the impression that the ZPD was Vygotsky's "central contribution" (p. 20). Certainly, the ZPD is perhaps the most well known of Vygotsky's concepts in Western educational research. Lerman (2003) explains the significance of the ZPD for education and educational research:

> *Vygotsky's well-known notion offers a description of the whole process of learning, whether it be from a teacher/authority, a peer, or a cultural product such as a text book, as well as a tool for studying learning. A wide range of studies have examined aspects of the zone of proximal development (2003, p. 103).*

This diversity of interpretations makes this a complex notion to review. Many researchers have attempted to categorise it in order to make sense of it. Examples of some of these are shown in Table 2 below.

Table 2: Examples of ZPD categorisations from reviewed literature

Researcher(s)	Field	Categories / Dimensions
Chaiklin (2003)	Educational theory	• The generality assumption • The assistance assumption • The potential assumption
Goos (2004)	Mathematics	• ZPD as arising from Scaffolding • ZPD as arising from Collaboration • ZPD as arising from Interweaving
Meira and Lerman (2009)	Mathematics	• Performance • Interaction • Semiotic mediation
Eun, Knotek and Heining-Boynton (2007)	Language and literacy education	• The goal of the ZPD • Who is going through the development and learning • Who is guiding the development and learning
Del Río and Álvarez (2007)	Psychology and media	• Who develops • With whom • What is developed • With what • How and where
Levykh (2008)	Educational Psychology	• The participants • Their interaction and collaboration • The types of tools used • The type of mediation used • The cultural-historical context

However, none of the categorisations above sat comfortably with me for this study and thus I endeavoured to make sense of the extensive range of interpretations for my own purposes. Thus from my reading I identified six categories of debate:

A. The type of space the ZPD is
B. Whose ZPD is created
C. The nature of interactions that take place in the ZPD and knowledge relationships
D. The function or purpose of the ZPD
E. The nature of the mediation or assistance provided
F. Promoted actions in the ZPD

These categories usefully provide analytic structure to my review of the field and are shown diagrammatically in Figure 2 below[7].

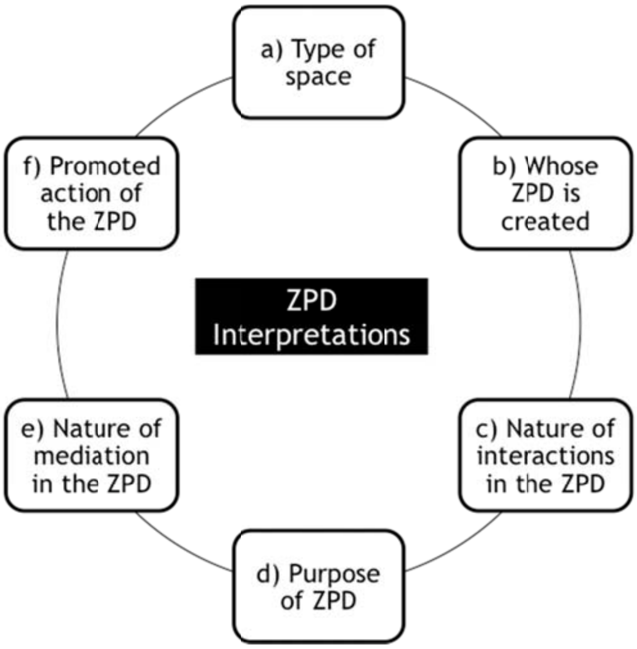


Figure 2: Categorisations of ZPD interpretations

It should be noted that these categories are not discrete and a single interpretation of a ZPD will not fall neatly into one category. Therefore, a researcher may conceptualise a ZPD using terms from different categories. In this definition by Radford for example, we see elements of type of space (relational, complex system) and the nature of interaction.

> *rather than an absolute concept, the ZPD is a relational one ... In particular, it is forged out of the interaction between students, and between the students and their teacher ... The ZPD is not a static thing that belongs to one particular student but rather a social, complex system in motion (Radford, 2010 p. 116).*

In the next section I discuss each category and list some words that reflect common interpretations evident in the literature. I also provide examples to illustrate the nature of the category.

A. THE TYPE OF SPACE

[7] I owe much to the work of the aforementioned authors in arriving at to my own categorisations of the myriad of ZPD interpretations.

Many interpretations of the ZPD describe it as a type of space: physical, static, symmetrical, asymmetrical, symbolic, semiotic, complex system in motion, life space, absolute, relational and dialogical are some examples. One of the first conceptions of the ZPD was that of a *physical space* in terms of being a fixed size or something physical in nature. This type of ZPD is

> *understood as a simple space of knowledge transmission: the space where the teacher dispatches knowledge to the student. [..]. In other no less unfortunate interpretations, the ZPD appears as something intrinsic to the student. Indeed, the concept of ZPD is often presented as if the student has his or her own ZPD, regardless of the sociocultural context within which he/she develops. (Radford, 2010 p.116)*

We see in this quote that the more traditional interpretation supposes that the ZPD is something that *belongs* to the learner and is carried around from one learning context to another. Kozulin and Gindis (2007) argue that there is nothing in Vygotsky's texts that suggest that the size of a ZPD is a fixed property of the child, remaining constant across age periods. Rather, Vygotsky suggested that the 'size' of the ZPD is "determined by the child's ability to benefit from collaboration with another in order to advance the child's performance beyond what was already achieved by non assisted performance" (Kozulin & Gindis, 2007, p. 354).

Meira and Lerman (2001, 2009) argue that the ZPD would be better conceptualised not as a physical space, in the sense of the individual's equipment (either cognitive or communicative), but as a symbolic space involving individuals, their practices and the circumstances of their activity. As a symbolic space the ZPD does not exist prior to the learning activity and comes about because of social and dialogical interactions between participants during teaching and learning activities. Similar to this notion of a symbolic space, Holzman (1997) suggests that the ZPD is "not a zone at all, but the 'life space' in which the so-called higher psychological processes in which human beings engage (such as speaking, thinking and problems solving) emerge and develop. The critical feature of the ZPD as life space is that it is *inseparable from the we who produce it"* (Holzman, 1997, p. 61). [Original emphasis]

B. WHOSE ZPD (Different kinds of ZPDs)

This second category includes interpretations in the literature that indicate the different kinds of ZPDs that can be created. The literature reveals individual ZPDs, learner only ZPDs, ZPDs for all participants, whole class ZPDs and multiple, overlapping ZPDs. I note here that the ZPD is a widely used notion in mathematics teacher education (see for example Goos, Galbraith, & Renshaw, 2002; Goos, 2004), so ZPDs can be created for adult learners too. Common interpretations assume that it is the child for whom the ZPD is created and that interaction and mediation is on a one-to-one or small group basis. Other researchers indicate that ZPDs are created for all participants in a context including the adults or teachers.

Whole class interpretations of the ZPD are less common. For example, Guk and Kellogg (2007) point out that educators have found it difficult to apply the notion of the ZPD in classrooms. Their study therefore turns its attention to whole classrooms of learners and their data shows that the way in which learners mediate tasks differs from the way in which teachers do. They suggest that teacher-student and student-student interactional mediations do not create two different ZPDs but instead lie within a single, whole class ZPD.

Allal and Pelgrims Ducrey (2000) describe a ZPD where the interactive aspects of the instructional setting potentially created multiple ZPDs. These vary from one student to another depending on the appropriateness of teaching interventions with respect to each learner’s present level of competence in the task under consideration.

C. THE NATURE OF INTERACTIONS and KNOWLEDGE RELATIONSHIPS

When discussed as part of the ZPD, interactions are interpreted in the following ways: collaborative, cooperation, bi-directional, equal / unequal, expert / novice, opposition of individuals, dialogical or social.

Wood, Bruner and Ross (1976) attempted to conceptualise and operationalise the ZPD using the metaphor of scaffolding where “more knowledgeable others” (usually adults) scaffold the learning process for the learner from assisted through to independent performance. This assistance enables the learner to build on his or her own existing knowledge and internalise new information. This interaction with a more knowledgeable other has also been called an expert-novice ZPD (for example Goos, Galbraith, & Renshaw, 2002).

This view, which Roth and Radford (2010) termed “opposition of individuals” (p.299) tends to result in unequal status learning as one person is seen as more capable than the other and attribute this interpretation of the ZPD to a “simplified reading of its original definition and primary sense” (Roth & Radford, 2010, p. 299).

Van Oers (2011) described this view as a “discrepancy-formula” (p.86) in that it defines the discrepancy or difference between a what a child can do alone and what the child can do under adult guidance. Van Oers argued that this misconstrues the ZPD as a place of transmissive teaching and learning. Radford (2010b) spoke too about this a being simplistic space of “knowledge transmission” (p.3).

In a different interpretation, researchers argue that there is learning potential in peer groups and the interactions are seen as working in or creating a bi-directional or collaborative ZPD (see for example Forman, 1989; Goos et al., 2002). This view is based on Vygotsky’s belief that children learn when playing with peers and that they spontaneously create a ZPD in play (Vygotsky, 1978). In this more egalitarian conceptualisation of the ZPD each partner possesses some knowledge and skill but requires the other persons’ contribution in order to make progress. A more knowledgeable other is therefore not a necessary condition for the emergence of a ZPD. Guk and Kellogg (2007) supported this and asserted that studies have shown that “ZPD may arise in the absence of a teacher” or that “teachers can neither create nor control zones” (p. 285).

An issue I have needed to address when presenting this categorisation framework at conferences is the role power plays in the ZPD. Power is frequently used to talk about the imbalance between teachers and students in terms of knowledge, control over the learning environment, ethnicity and gender and the power that students have over their own learning. While the notion of power is inherent in each of the categories, and is dependent on how the ZPD is conceptualised and described, it is particularly visible in this category of relationships. For example, a ZPD that depends on transferral of knowledge and/or skill to a learner via a tightly planned transmissive teaching process, by a more knowledgeable or more competent other, reveals an imbalance in power. In this scenario, the nature of the interactions and direction of learning is tightly controlled by the adult, thus resulting in what Roth and Radford (2010) termed ‘opposition of individuals’ (p.299) or an asymmetrical ZPD (Marsh & Ketterer, 2005; Roth & Radford, 2010). On the other hand, conceptualisations of the ZPD that encourage interaction between students and those that give students more control over their own learning, could be seen as redistributing the power in the learning environment where it is possible for all participants to be both learners and teachers, thus making the interactions and power relations in a ZPD more symmetrical.

D. THE FUNCTION OR PURPOSE OF THE ZPD

In many conceptualisations of the ZPD, the function or purpose is a way of seeing the relationship between learning and development. As previously mentioned, in Vygotsky terms, the ZPD does not refer to learning in general, only to learning that results in development. Interpretations in this category see the purpose of the ZPD as learning or developing subject matter, mastering and practising specific skills, development (interweaving) of everyday and scientific concepts, developing mental (cognitive) functions and psychological processes. Another dimension that appears in more recent literature is that of developing affective functions in children.

Levykh (2008) added the dimensions of emotion and desire to the ZPD. He argued that the ZPD encompasses affective functions as well as cognitive, social, cultural, and historical dimensions and views the ZPD as a dynamic process that “reflects constant changes in the emotional connections amongst participants” (p.91). He pointed out that Vygotsky was a strong opponent of treating intellectual and affective aspects of human life as separate and therefore argues that learning and development take into account the whole person. He concluded, “a safe and emotionally positive collaboration creates a more complete ZPD” (p.92).

E: NATURE OF MEDIATION PROVIDED

In this category of interpretations, researchers focus on the meaning, value and quality of mediation or assistance provided. Interpretations include transmissive, pre-planned, in-the-moment, instructional dyad, more knowledgeable other, more competent other, interweaving, quality of verbal support.

Goos (2004) put forward an interpretation of the ZPD that she called ‘interweaving’, based on Vygotsky’s conceptualisation of the ZPD as the distance between learners' intuitive notions (everyday or spontaneous concepts) and the formalised (or scientific) concepts of a particular academic community. In this version of the ZPD, mature knowledge is achieved with the merging of everyday and scientific concepts by interweaving the two conceptual forms, not by replacing the everyday concepts with scientific ones as seen in a transmission model of teaching.

In a different interpretation of the ZPD, Goos (2004) re-framed the notion of scaffolding based on the type of mediation provided. In the more transmissive interpretations of the ZPD based on the metaphor of scaffolding, the mediation (or assistance) offered is in the form of demonstration and imitation, teaching focuses on pre-planned sequenced tasks. In a situation where the learner actively contributes to the creation of the ZPD, mediation from the teacher changes and focuses on structuring social interactions between students by asking them to participate in mathematical thinking (Goos, 2004).

F: PROMOTED ACTIONS IN THE ZPD

Included in this category, which originates from the Zone of Promoted Action in Zone Theory, are ZPD interpretations that incorporate the context and the possibilities the ZPD offers for the participants. Typical interpretations include: play, role-play, imitation, ahistorical, context-free, cultural-historical context, the ability of learner to benefit and take advantage of the assistance, the types of activities and tools promoted and the cultural value of these activities and tools to the participants.

For example van Oers and Duijkers (2012) argued for play as a valuable context for learning and teaching. They based their work on Vygotsky's idea that a ZPD is created through role-play. Their data suggests that a concept of learning can be developed that allows goal-directed teaching and learning by young children in the context of role-play under the guidance of more knowledgeable others. In other work, van Oers (2011) spoke about *imitation* being the "essence of the ZPD" (p. 86). He described imitation in terms of the meaningful reconstruction of cultural activities where the meanings of both the adult world and the child come together not the "meaningless copying of actions" (p. 86).

In another example, Lerman (2001) stated that it is the promoted learning activity that sets up the ZPD. For him the learning activity includes the task set by the teacher, the texts, the ethos of the school and classroom and more importantly the "possibilities arising out of the particular mix of the actors that day, even that moment" (p.5).

This review of the different ZPD interpretations provided my research with an overview of this complex notion. From the range of recent publications it is clear that the ZPD is still current in mathematics education research. I close this discussion with a cautionary note from Daniels (2008). He pointed out that there is a “need for greater clarity in the explication of the background assumptions that are in play when the ZPD is deployed” (p.25) along with a need to clarify the scope of the “social cultural-historical formation that is envisaged within the ZPD” (p.25). These observations are crucial to this study. The design and description of the empirical field (the context of the after school clubs) using Zone Theory (see section 2.4 below and Chapter Three) and the analysis approach for question two, detail the background assumptions, clarify the scope of the study and provide the social and cultural context of the study.

As a result of what transpired in the pilot club and how I interpreted these experiences, the work of this study is considered to align with the interpretations of the ZPD that support a deeper understanding of the ZPD in context in terms of the participants, their interaction, collaboration and activity, the types of tools used, the type of mediation used and the cultural-historical context (following Levykh, 2008). Thus my interpretation favours the ZPD as a symbolic space that encompasses the whole person. The emergence of a ZPD is enabled by presenting activities that are meaningful to the learner, activities that can be accomplished with assistance, ones that allow learner agency to benefit and take advantage of the assistance from others. The evolution of this conception for my study is explained in Chapter Three.

2.3.4 SECTION 2.3 CLOSING REMARKS

In this section, I have positioned myself in a broader Vygotskian theoretical framework and have relayed how and why this framework was chosen for the study. Key constructs, which are particularly relevant to my research and analysis that underpin Vygotsky’s theoretical perspective, have been unpacked. Many of these will be referred to again in the following sections of this chapter, particularly in Section 2.5 that reviews the constructs inherent in research question two. Two further sets of constructs remain to be explored in the literature: 1) those that relate to the conceptualisation and design of after school programmes and other learning programme designs and 2) those that unpack the ideas in my research questions.

2.4 AFTER SCHOOL PROGRAMMES & CLUB DESIGN CONSTRUCTS

As a member of the SANC project research community, I have the unique opportunity to participate in a number of maths clubs as both club mentor and as a researcher. Furthermore, I am the Maths Club co-ordinator and have been specifically tasked with the design and related facilitator training of the Maths Club programme. This triple role enables an on-going, powerful reflexive practice to develop between the club learning programme design, implementation and my research and is explored further in Chapter Four. While club design is not the focus of my research, it frames the way in which the case study clubs were formed and the intended practices and activities, forms of participation, interactions and socio-mathematical norms in these clubs. Since the clubs are the empirical field for my research, I elaborate on this below. First I review literature about after school programmes in general, followed by specific conceptualisations of clubs for the SANC project. I look specifically at the dual nature of the club design and then turn to look at how Zone Theory has been used as the design process framework and discuss its importance for other aspects of the study. Finally, I review the concept of socio-mathematical norms and their importance for establishing the club ethos.

2.4.1 AFTER SCHOOL PROGRAMMES

> *Afterschool programs are a critical first step in the process of changing not just how we educate our children, but how we come together, in partnership - school and community - to ensure their success* (White, 2005, p. 8).

This quote suggests the importance of providing after care programmes for children. It is believed that when a neighbourhood or home context are “less than desirable”, after school programmes can bridge the gap between these and the school (White, 2005) and is particularly pertinent to the South African context. It is with these ideas in mind that I explore literature on after school programmes. It is worth pointing out that much of literature pertaining to after school programmes originates from the United States. In general, literature on after school programmes uses the terms ‘out-of-school time’ (OST) or ‘after school’. In reviewing the literature, I shall use whichever term the original authors use. Lauer, Akiba, Wilkerson et al. (2006) state that OST refers to the hours in which school-age children are not in school and that during these hours, children are doing something other than activities required by school attendance. After school programmes could be seen as a sub-category of broader OST programmes as other programmes in the US run during summer holidays, before school and over weekends. In the US, after school programmes have been in existence for many decades (Bodilly & Beckett, 2005; Halpern, 2000). Many programmes target at-risk children which range from basic after-care, through academic development to specific social, sport and artistic programmes. Durlak and Weisberg (2007) indicate that, in the United States, there is an increasing interest in after school programmes that can provide children with a "safe and supportive adult-supervised environment and offer them various growth-enhancing opportunities, including activities and experiences that promote academic, personal, social and recreational development" (p.5).

One of the aims of the SANC project's after school maths clubs programme is to promote and potentially improve mathematical proficiency in learners; this can be seen as a focus on academic development as opposed to sports development for example. Hence the remainder of this review will focus on OST programmes that revolve around academic development. In this regard, Beckett, Borman, Capizzano et al. (2009) highlight that "OST is an opportunity to supplement learning from the school day and provide targeted assistance to students whose needs extend beyond what they can receive in the classroom" (p.1).

Beckett et al.'s (2009) practical guide for structuring OST programmes to improve academic achievement presents recommendations (and approaches for implementing the recommendations) including supportive relationships, opportunities to belong, positive social norms and opportunities to learn a range of skills (intellectual, social, emotional and psychological). These recommendations, approaches and features resonate with the way our clubs are designed and the ethos promoted and will be exemplified in the discussion in Chapter Three. Next, I review literature related to the effectiveness of OST programmes.

Research on the effectiveness of after school programmes

Research and reports originating from the USA from 2007 onwards focus on the impact and effectiveness of after school programmes. These reports tend to evaluate groups of programmes at city, state or national levels. Some focus on evaluation of academic programmes and others on the development of social and personal skills. The Executive Summary of one such report (Durlak & Weissberg, 2007) summarises the positive effects of OST programmes as follows:

> *young people benefit when they spend time engaged in structured pursuits that offer opportunities for positive interactions with adults and peers, encourage them to contribute and take initiative, and contain challenging and engaging tasks that help them develop and apply new skills and personal talents (p. 5).*

In 2006, Lauer et al. carried out a synthesis study of 35 American OST programmes concerned with reading and mathematics. Amongst the conclusions they presented were that OST programmes can have positive effects on achievement in reading and maths. Furthermore, they highlighted that future research and evaluation studies should document the characteristics of the OST programme and how the programme is implemented, as more evidence is needed of what characterises effective programmes. This final point is relevant to this study as I wish to contribute to research in this respect. Finally, I briefly review what the literature reveals about the benefits and success factors of OST programmes.

Research on the benefits of and critical success factors in after school programmes

Papanastasiou & Bottiger (2004) described the advantages and benefits they found in voluntary middle school (grades 5 to 8) maths clubs held before school time in an urban school in the US Midwest. They argued that clubs in general have the advantage of providing opportunities for students to develop personal self-esteem, inquiring minds, relatively close human relationships and a sense of belonging and purpose or usefulness and, as low stress environments, clubs enable students to learn about teamwork and of the importance of cooperation and mutual support. These cohered with Graven's (2011) reasons for starting clubs as a key SANC project intervention.

Their view is supported by another American study by Albers, Smith, Caldwell et al. (2008) focussed specifically on mathematics clubs for grade 3 to 8 learners run during 2007 at an inner city school in North Carolina. They reported that OST programmes create greater engagement in learning and higher academic performance and learners who participate in after school programmes tend to develop interests and skills that stay with them throughout their lives. Furthermore they stated that the schools hosting the OST club(s) are also positively impacted because it creates a more positive image in the community. Similarly, a Harvard Family Research Project (Little, Wimer, & Weiss, 2007) listed the academic outcomes associated with participation in after school programs as better attitudes toward school; better performance in school (as measured by achievement test scores and grades);

improved homework completion and better engagement in learning. Amongst the social and emotional benefits, they included improved self-confidence, self-esteem; improved social and communication skills and/or relationships with others (peers, parents, teachers); improved feeling and attitude towards self and school and development of initiative. Indeed, a key reason for the clubs in the SANC project has been to shift learner mathematical dispositions (see Graven, Hewana, & Stott, 2013; Graven, 2013a).

Little et al. (2007) were concerned that not all research and evaluation studies have shown benefits. They believed that this provoked useful discussion and research about the *conditions* necessary to deliver effective programmes. They pointed out that a critical component of achieving high quality in after school programmes is to intentionally develop programmes that “focus on promoting targeted outcomes through well-organized and engaging activities” (2007, pp. 12–13). Similarly, Durlak and Weissberg (2007) stated that programmes that focus on using the ‘*SAFE*’ (sequenced, active, focused, explicit) design features show positive findings.

Aside from these studies, the literature on primary school academically oriented clubs is relatively limited, particularly so in Africa. Peer reviewed literature on school maths clubs in South Africa is non-existent except for Graven’s (2011a) article referred to earlier. In the absence of formal research on OST programmes in South Africa, an internet search for after school programmes in South Africa revealed only four programmes, none of which has a mathematical focus. These are shown in Table 3 below. While different types of OST programmes are shown, from the information provided on their websites, all seem to exhibit at least some of the characteristics discussed in this section.

Table 3: Sample of South African OST Programmes

Name	**Description from website**	**Grade / age focus**	**Learning Area**	**Website**
Boost Africa Foundation	Assist the children with their literacy and numeracy skills through educational worksheets and games and incorporate extra-mural activities to stimulate their young minds.	pre-school and primary school	Literacy and numeracy	http://www.boostafrica.com/projects/after school-programs.html
Mdumbi Education Centre	After school enrichment in all learning areas	None stated	General	http://www.transcape.org/cms/index.php/After school-Enrichment.html
Science Clubs	Science clubs are organizations intended to provide opportunities for students to explore science. The clubs are usually initiated by an educator/learners at a particular school, science communicator/educator / parent or a scientist/engineer	None stated but possibly high school	MSTE (Maths, Science, Technology and Environmental)	http://scienceclub.saao.ac.za/
Boys and Girls Clubs of South Africa	Focuses specifically on the out-of-school experience during those crucial, unsupervised hours when vulnerable, at-risk youth in disadvantaged communities are neither at school nor at home and are most prone to destructive influences. Youth aged 6 -18 spend professionally managed, quality-time during non-school hours, having loads of fun, building character, self-discipline, focus and direction in life.	Ages 6 to 18	General	http://www.wecanchangeourworld.co.za/Profiles/NGONPO/BoysandGirlsClubofSouthAfrica/tabid/273/Default.aspx

2.4.2 CLUB EMERGENCE AND SANC PROJECT CLUB CONCEPTUALISATION

Graven, who holds the South African Numeracy Chair at Rhodes University conceptualised after school clubs as an integral part of the research and development activities of the Chair. In a 2011 article Graven (2011a) shared a story of how prior to the SANC project, she formed a club that deliberately created a more engaging, confidence building and participatory form of practice and one that focussed on the disruption of passive teacher-dependent "ways of being" (p. 3). She argued that clubs are an "opportunity for disrupting passive learning culture and deliberately working with learners to become confident mathematical participators" (p. 5). She acknowledged that some clubs may simply be an extension of mathematics classes in after school time and that there is nothing inherent in an after school maths club that will enable the formation of positive learner identities, only that they hold the increased "potential for providing an enabling space" (p.5) since they are less controlled by curriculum and school demands. Because of her experiences with this club she introduced clubs as part of the SANC project's learner focused intervention activities.

In a Maths Club Funding Proposal, Graven (2011b) gave four reasons why clubs could be beneficial. These are summarised as follows. Remediation work that consolidates mathematical foundations is an urgent requirement for many learners in South African schools and clubs could provide a place for this type of remediation to take place. Clubs could also create opportunities to challenge and extend those learners who are coping at their grade level and perhaps to strengthen their mathematical dispositions and confidence. Clubs could also provide an opportunity to strengthen groups of learners in class, who could serve as catalysts for furthering mathematical proficiency of others in their classes. Finally, clubs could provide extended learning opportunities for learners to work on mathematics in OST.

In this same proposal, she suggested that an intended outcome of clubs would be to "improve both learner numeracy performance and learner dispositions (attitudes and ways of participating in numeracy practices)" (p. 3). Once strengthened, these groups of learners should enable participating NICLE teachers to "raise expectations of learners and engage with conceptually deeper, more connected mathematical activities and questioning" (2011b, p. 3).

She also indicated that in a second phase of the clubs, the SANC project could begin to widen the scope of people running the clubs. For example teachers (from both the NICLE community and from the local community) could be invited to run clubs using the SANC project club model. One consequence of teachers running clubs would be that teachers are provided with an opportunity for exploring new ways of working outside of the classroom environment. Graven pointed out that there is some research which suggests “teachers are more willing to try out new more learner-centred practices in after school activities” (p.3)[8]. As indicated in Chapter One, a key role that I perform in the SANC project is facilitating workshops for facilitators / teachers who wish to run after school maths clubs.

Furthermore, in 2011, through SANC project’s associated teacher development project (NICLE) Graven observed a range of classroom practices of teachers participating in SANC project activities. She and I contrasted some of the key observed practices with our intended club practices as indicated in Table 1 earlier. These contrasts have become the principal guidelines on which the creation and design of SANC project clubs are based. The right hand column reflects a number of features mentioned in the literature review above. For example norms, small group work, engaging learning experiences and so on. In this respect, the SANC project defines the mathematics clubs as informal, after school clubs focused on developing a supportive learning community where learners can develop their mathematical proficiency, make sense of their mathematics and where they can engage and participate actively in mathematical activities. Individual, pair and small group interactions with mentors are the dominant practices with few whole class interactions.

[8] This second phase began in April 2013 with an article in the local Grahamstown newspaper (Grocotts) explaining clubs and inviting educators to participate in workshops. The first workshop for teachers took place in May 2013.

2.4.3 DUAL NATURE OF THE DESIGN: ACQUISITION AND PARTICIPATION

Based on this initial conceptualisation for the clubs, one specific aim within the SANC project was for the clubs to promote individual learner mathematical proficiency as well as active participation. This aim brings together acquisition and participation (having and doing). This dual approach to working with the two metaphors is by no means unique to our clubs and various studies provide mathematical examples where this has taken place (see for example Askew, 2004; Goos et al., 2002; Jaworski & Potari, 2009). The acquisition and participation metaphors are useful ways of accounting for evolving mathematical proficiency and participation as they occur in the social context of the clubs. Figure 3 shows my interpretation of Sfard's metaphorical mappings (1998) in the club context for this study. The boundary line between the two is intentionally blurred as I have needed to work seamlessly with the dual nature of the two notions in my case study clubs.

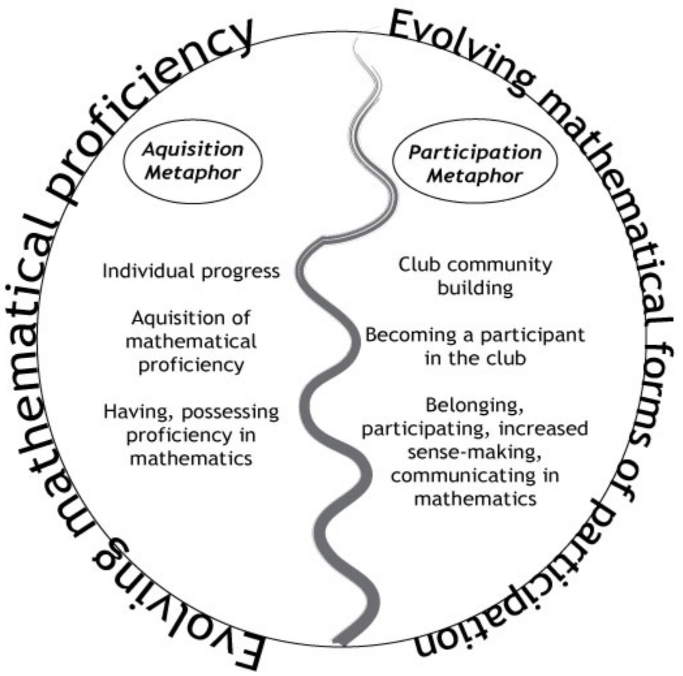


Figure 3: Club design metaphorical mappings (adapted from Sfard, 1998 p.7).

The club programme design process, informed by Zone Theory (discussed later) allowed me to simultaneously pay attention to the types of interventions, activities, socio-mathematical norms and the environment we had conceptualised. Zone Theory accommodated this relationship and is exemplified later.

The left side of Figure 3, *evolving mathematical proficiency*, is discussed in further detail in section 2.5 in this chapter. Here I look more closely at the right side of the diagram and explore what *mathematical forms of participation* are promoted in recent literature as enabling mathematical proficiency. Boaler (2002) suggested the participation that is required of learners who learn in participation-oriented environments is very different to that expected of learners in more traditional, acquisition-based classrooms. They are required to contribute *different aspects* of themselves as well as contributing *more* of themselves. Further, Boaler and Greeno (2000) argued that mathematics learning *is participation* in mathematical practices and they propose that learning of mathematics can be seen as a ‘trajectory of participation’ in the practices of mathematics.

David and Watson (2008) argued that when we focus on participation, we also need to look at the “extent to which the participation is mathematical” (p. 49). They claimed that it isn’t enough to simply say that the learners participated in various practices. They advocated that we need to look for the kinds of mathematical activity that are *afforded* in classroom interaction sequences and how learners are *constrained* by teachers (or adults). These ideas are considered in the discussion of the application of Zone Theory that follows.

For this study it was important to be able to qualify the nature of participation and to be able to determine whether it was mathematical or not. For example, I could say that learners were participating in the clubs simply by showing up every week, but this did not give a sense of either their mathematical participation in the clubs or of how their mathematical proficiency evolved. For that to be evident, I needed to look at how they participated in the practices promoted / enabled by the club, the extent to which that participation was mathematical, what they give of themselves and what they contributed to the community.

2.4.4 LEARNING PROGRAMME DESIGN FRAMEWORKS

In section 2.3, I spoke about the way that the SANC project work is framed as a community of practice and situated learning. In searching for a framework around which to structure the maths club learning programme I reviewed designs that fell within this broader theoretical framework, focussed on those that were related to mathematics education in some way and were recent in research terms. Another key requirement for the club design approach was *flexibility*. The SANC project maths club initiative was in its infancy and I had yet to pilot a club. It was imperative that the learning programme design was flexible enough to cope with changes as I grew more confident, collected and reviewed data and moved forward.

Goos' work on Zone Theory with various people (Galbraith & Goos, 2003; Goos et al., 2007a; Goos, 2009) particularly resonated. Her work (primarily in teacher development and student teacher development) is practical but also well supported theoretically. Following the pilot I explored Zone Theory as a basis for the design principles in the SANC project clubs.

2.4.5 ZONE THEORY

In this section I examine the nature of Zone Theory (ZT). The theory served two purposes in my work: one, it provided a design mechanism for the club learning programme and secondly, it provided a powerful explanatory tool for describing my empirical field in later chapters. Galbraith and Goos (2003) argued that Zone Theory contributes a structure and vocabulary to make features of instructional design explicit and I made use of this aspect in my study.

Valsiner (1997) introduced two additional zones in relation to Vygotsky's (1978) zone of proximal development namely the *zone of free movement* (ZFM) and the *zone of promoted action* (ZPA). These described the structure of a child's development in terms of the environment and relationships between the child and other people in the environment (Goos et al., 2010). The two additional zones give a better understanding of how the ZPD operates in a specific learning context. It creates a picture of the physical and cultural space in which the ZPD is situated. The ZFM, ZPA and ZPD can be seen as structures through which an adult or more knowledgeable other constrains or promotes the learner's thinking and acting and as such the ZFM/ZPA combination *interactively generates* the environment in which that learner develops (Blanton, Westbrook, & Carter, 2005).

Zone Theory in educational research has been used in relation to teacher development or teacher practice particularly in technology enriched teaching and learning environments (see for example Brown, 2003; Galbraith & Goos, 2003; Goos et al., 2007a; Goos, Dole, & Makar, 2007b). I use the theory in conjunction with a professional development framework proposed by Goos and her colleagues (Goos et al., 2007).

Overview of Zone Theory

Whilst the ZPD may be a well-known concept to most in educational contexts (and has been discussed in detail in section 2.2 above), the ZFM and ZPA are less known and so I provide a brief overview of the three zones in the context of Zone Theory and the relationships between them.

Zone of Free Movement (ZFM)

In essence, the ZFM is a function of what is allowed for the learner by the adult. On the one hand, the way an adult organises the ZFM anticipates the nature of the child’s thinking about the concept being taught at the moment and in the future. In this sense, the ZFM ultimately channels the direction of development for the child, providing a framework for cognitive activity, learning and potential development (see Blanton et al., 2005; Galbraith & Goos, 2003; Galligan, 2008; Goos et al., 2010, 2007).

Zone of Promoted Action (ZPA)

This is the set of activities, objects, or areas in the environment by which an adult or more knowledgeable other attempts to persuade a learner to act in a certain way and as such describes what the adult is promoting. However the learner is under no obligation to accept what is being promoted as in the case where learners may not wish to actively participate (Blanton et al., 2005).

The ZPA should ideally be in a learner’s ZPD. In other words, the ZPA should promote activities that stimulate the emergence of the ZPD. For example, having poor mathematics skills in a class which assumes basic mathematics skills may result in the learner’s inability or reluctance to participate or learn and the absence of the emergence of the ZPD for that learner. On the other hand those learners who believe they already have the necessary skills may also not participate (Blanton et al., 2005; Galbraith & Goos, 2003; Galligan, 2008; Goos et al., 2010, 2007).

Zone of Proximal Development (ZPD) in Zone Theory

As we have seen from the discussion above, the ZPD is conceptualised in many different ways. In Zone Theory, the ZPD is described as the "a set of possibilities for development that are in the process of becoming actualised as individuals negotiate their relationship with the learning environment and the people in it" (Goos et al., 2007).

In designing learning programmes, Goos, Dole and Makar (2007a) drew on the work of Loucks-Horsley, Love, Stiles, Mundry, and Hewson (2003) to "capture the decision making processes that are ideally involved in planning and implementing programs" (Goos et al., 2007). Goos et al.'s (2007) adapted framework is shown in Figure 4 below, as this is the framework used as the basis for the learning programme design in this study.

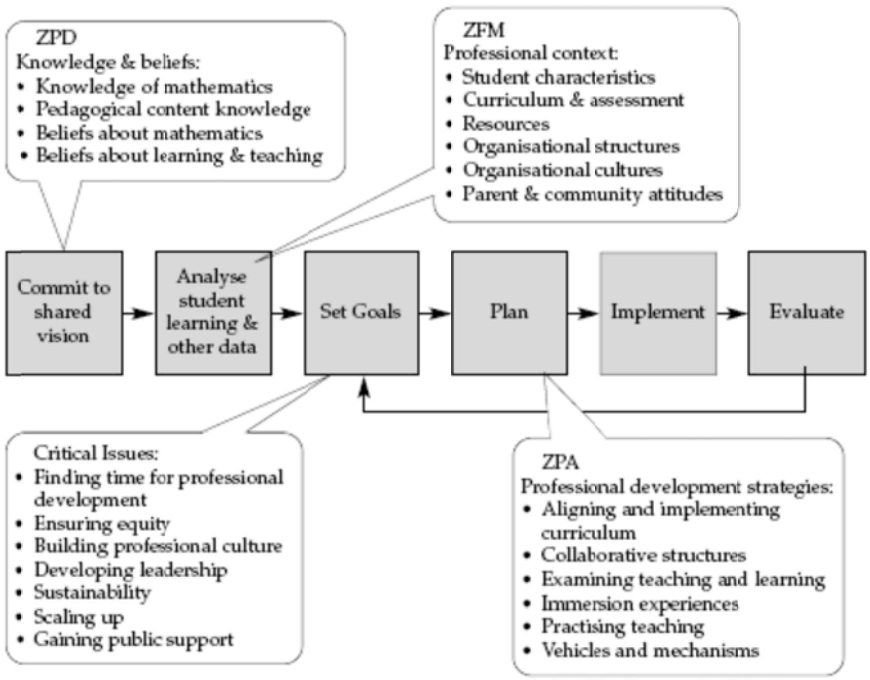


Figure 4: Adapted framework for planning and implementing programmes - Goos et al. (2007b, p.27)

How I adapted this combined framework for the club design

In order to use this framework for the club design, I inserted the contextual elements relevant to my study and the SANC project into the framework used by Goos and her colleagues (2007). This simplicity in usage characterises the power of this framework and will perhaps illuminate how other researchers and educators could use it for their own programme designs. A summary of the design process for this study is shown in Figure 7 on page 93 in Chapter Three where I talk about the clubs in much greater depth.

Why I chose this framework

As the club co-ordinator for the SANC project clubs, the framework allowed me to take into account various aspects of the project and club programme. Additionally, as a process it is easily explainable to others and will contribute to ensuring that the Maths Clubs are sustainable after the research project finishes. Finally, the framework provided me with a process for setting goals, planning and evaluating the on-going learning programme in the clubs. This allowed ownership of the process as well as a way of ensuring that it fitted into the objectives of the broader SANC project. Also because the process is iterative and cyclical it allowed evaluation of what was and what was not working on a regular basis and this was used to plan and implement subsequent actions and activities in the clubs. I undertook this kind of evaluation process after the pilot club in 2011 (as discussed in Chapter 3). Finally, the framework accommodated both the acquisition and participationist aspects of this study.

How Zone Theory informs the broader study

Jaworski (2007) talked about developmental research as being complex and suggested that there are two ways of engaging with a design process. One way is to study the design process itself and the other is to use the design process as a research process. If we look at the Goos et al. (2007) framework from the perspective of a research process, it offers various options.

Goos (2006) highlighted that different *configurations* of the ZPD, ZFM and ZPA will arise in every study and it is these differing configurations that can be used to analyse and discuss the data collected during the study. Indeed, I saw differing configurations arise during the pilot study and I discuss these in detail when discussing the Empirical Field[9]. Galbraith and Goos (2003) pointed out other ways that Zone Theory can be used for reflection and analysis of learning sessions:

> *among other purposes they provide frameworks for enhancing the analytic quality of lesson observation and planning, and for principled evaluation of classroom segments in teacher education programs* (Galbraith & Goos, 2003).

While I am not using Zone Theory as an analytic tool, this notion of differing configurations opened a way for me to *describe* my empirical field and to *structure* discussions in subsequent chapters using a framework and vocabulary that was congruent with both the dual nature of the study as well as with the broader theoretical framework of the Vygotskian perspective. In this way ZT helped to create a picture of the physical and cultural space in which the ZPD is situated and as Goos et al. (2010) point out, to describe the structure of the club learners environment and the relationships between the learners and other people in the clubs.

In addition, by using Zone Theory in the ways described in this section, I contribute to the body of work on Zone Theory and hence contribute to its usage as both a design process and an explanatory tool.

2.4.6 CLUB ETHOS: SOCIO-MATHEMATICAL NORMS

Earlier I contrasted the club environment to classrooms. One key aspect of the club environment is to develop an exploratory ethos. It is important to take into account the socio-mathematical norms of the club, as these norms are an integral part of the club design in terms of the Zone of Free Movement (ZFM). Socio-mathematical norms can and have been conceptualised under many different names and have many different nuances. Examples include sociocultural norms, socio-mathematical norms and so on. Cobb, Wood, Yackel and McNeal (1992) and Yackel and Cobb (1996) introduced the term "*norms*" to designate the mutual expectations that are established in the classroom through the interactions between the teacher and the students. In their work, Yackel and Cobb (1996)

[9] In collaboration with Mellony Graven, I published two articles on this aspect of the design during the course of my research (see Graven & Stott, 2012b; Stott & Graven, 2013b)

identified three norms in mathematics classrooms: mathematical, socio-mathematical, and social.

For the purposes of this study, I focus on the *socio-mathematical* norms which are the "normative aspects" (Yackel & Cobb, 1996, p. 458) of classroom activity that are related specifically to mathematics, such as the ways in which decisions are made regarding the quality of a mathematical argument (Yackel & Cobb, 1996). Hunter (2008) explained that these socio-mathematical norms evolve from mathematical activity between all classroom participants as they are "negotiated in the discursive dialogue" (p. 31). Mottier Lopez and Allal (2007) pointed out that this negotiation of shared meaning can involve a "lengthy sequence of encounters and transactions between students" (p. 264) and teacher in the classroom. The "classroom microculture is the setting in which these encounters and transactions occur" (p. 264).

The '*Effective Teachers of Numeracy'* study (Askew et al., 1997) revealed a number of connectionist teaching characteristics that cohere with the view of learning presented in this chapter and which relate to the *socio-mathematical* norms promoted in my case study clubs. Of note are those that indicate that learners become numerate through "purposeful interpersonal activity based on interactions with others" (p. 35) and that numeracy teaching is based on "dialogue between teacher and pupils to explore understandings" (p. 36). The characteristics of a connectionist orientation also gave myself and other club mentors practical suggestions for ways of promoting numeracy in the clubs and for explaining our beliefs about what numeracy is and how children become numerate.

My role in establishing socio-mathematical norms in my case study clubs

As indicated earlier, with the learning perspective adopted for this study, the teacher (or in my case, mentor) holds a pivotal role in structuring learning activities and social interactions in learning and development. Here I discuss my intended role in establishing the socio-mathematical norms in my after school clubs. In attempting to portray how learners get access to these rules, Van Oers (2001) started by defining what he understands to be "real mathematical activity" (p. 63). For him this is activity that is "accomplished when one legitimately participates in a mathematical practice, either by acting mathematically in an acceptable way, or by discussing mathematical or discursive mathematical actions" (p.71).

In terms of initiation of learners into this practice, the teacher (mentor) becomes central to the classroom discourse but not as the person with the 'power' and knowledge. Rather, the teacher (mentor) is a partner in the activity, suggesting solutions, questions and objections as well as being able to introduce new historical and cultural elements into the discourse that the learners could not otherwise propose by themselves (van Oers, 2001).

These norms are important for this study, as they describe what practices I encourage the learners to participate in and what practices I, as the club mentor initiate the learners into. My role is central in this. These norms concern expectations about how mathematical activity should be carried out, concern the type of discourse and mathematical talk that is likely to foster productive participation in the club mathematical community and relate to the qualities of mathematical participation and concern the expected forms of social interaction in a mathematical community. In addition these norms are important aspects of developing some of the strands of mathematical proficiency such as adaptive reasoning and productive disposition which are discussed in Section 2.5.

2.4.7 SECTION 2.4 CLOSING REMARKS

In this section I have reviewed literature on various after school programmes and highlighted some benefits and success factors. I have drawn specifically on Graven's (2011a) experiences with after school clubs in South Africa and unpacked her initial conceptualisation of the SANC project maths clubs, which is the empirical field for my research. I have looked specifically at how the dual nature of the study relates to the club design. I have elaborated how Zone Theory informs this study in various ways. Finally, I have reviewed the intentionally promoted socio-mathematical norms in my two case study clubs. This is not to assume however that other norms have not been unintentionally promoted. Examination of these is however beyond the scope and focus of this study.

In the next section, I unpack the concepts and constructs inherent in my two key research questions and look to the literature to situate, to define them and review the issues and debates surrounding each.

2.5 THEORETICAL FRAMEWORKS FOR RESEARCH QUESTIONS

As discussed, Vygotsky's view of learning and development encompasses both the learning that takes place in an individual and the social context that influences that learning and within which learning takes place. The dual nature of this study (acquisition and participation) reflects Vygotsky's view, as do my two research questions. In addressing research question one I zoom in to look at the individual learners in my case study clubs. In question two I zoom out to look at the broader participation within the clubs and specifically at the nature of the mediation between the participants that enables or constrains the emergence of ZPDs in club learners. In the sections that follow I review the theoretical frameworks and constructs for each research question in turn and briefly describe the data instruments used for each question.

2.5.1 THEORETICAL FRAMEWORKS INFORMING RESEARCH QUESTION ONE

Research question one: How do learners' mathematical proficiency levels evolve (if at all) over the period of participation in the maths club?

This question zooms in on individual learners. Using Simon's (2009) notion of what we look *with* and *at*, for this question I looked *with* a social-cultural perspective *at individual learners* and their *mathematical proficiency progression* over time. This lens or gaze allowed me to describe each learner's mathematical proficiency progression (in terms of what they internalised) during his or her participation in the club using the Vygotskian view of learning and development I discussed earlier.

The data that I collected for research question one was centred on each individual learner, and revealed both rich qualitative data and quantitative data. Two instruments generated both types of data: the MP interview and a set of fluency assessment activities. The MP interviews were structured to use the *Learning Framework in Number* (LFIN) (Wright, Martland, Stafford, et al., 2006). This framework provides examples of assessment items that enable one to gauge learner *progress* through various stages of numeracy development. The Methodology chapter gives a detailed discussion of this instrument and framework. Through analysis of this data over time, I was able to see how learners evolved and whether learning was taking place for each individual learner i.e. how they were coming to know or acquire mathematical knowledge. This research question is about individually having or knowing something, about individual possession of knowledge which situates it with the acquisition metaphor (Sfard, 1998). By zooming in on the individual learner, I foreground and describe each learner's progressing levels of mathematical knowledge construction based on their previous mathematical learning (evidenced by what they could and could not do or answer in the Mathematical Proficiency interview). In addition, by considering their pre-existing understandings (evidenced by the methods they use to answer interview questions) I was able to describe their progress over time in Chapter Five. The theoretical framework and constructs that enabled me to frame my analysis of question one are discussed below.

Mathematical proficiency

As mathematical proficiency is the key construct for research question one, as well as key construct for the SANC project, I define this proficiency. The working definition of numeracy for the SANC project was obtained by combining, extending and adapting the two seminal studies of Kilpatrick, Swafford and Findell (2001) and Askew, Brown, Rhodes, Johnson and William (1997) as discussed in Chapter 1.

In light of public concern in the USA regarding how well children learn mathematics, the National Research Council produced a report called '*Adding it Up: Helping Children Learn Mathematics*'(Kilpatrick et al., 2001). The report maintained that mathematical procedural fluency has been the focus of instruction in the past and has been over emphasised. They contended that much more is needed to prepare learners for the world and for personal success. All students should and can be mathematically proficient. Proficiency is an important foundation for further instruction in maths as well as for further education in fields that require maths. But more importantly, they claimed that in order for people to participate fully in society, they must know basic mathematics.

Their research led them to adopt a "composite, comprehensive view of successful mathematics learning" (p. 5). They recognised that no term could completely capture all aspects of mathematics, so they chose the term '*mathematical proficiency'* to comprise what they think it means for anyone to learn mathematics successfully. They saw mathematical proficiency as having *five interwoven* strands:

- *conceptual understanding: comprehension of mathematical concepts, operations, and relations*
- *procedural fluency: skill in carrying out procedures flexibly, accurately, efficiently, and appropriately*
- *strategic competence: ability to formulate, represent, and solve mathematical problems*
- *adaptive reasoning: capacity for logical thought, reflection, explanation, and justification*
- *productive disposition: habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy* (Kilpatrick et al., 2001, p. 5)

They emphasised that these five strands are separate yet interwoven and interdependent. Mathematical proficiency is only present when all strands are developed and proficiency develops over time. These proficiencies, when taken together, can lead to progressive mathematics learning. Askew (2012b) likened this inter-relationship to learning to play the piano whereby becoming proficient in mathematics means that it is necessary to engage in certain actions before one is fully proficient in them. "Becoming a proficient mathematician means working with all of the proficiencies - fluency, problem solving, reasoning and understanding - from the beginning" (Askew, 2012b, p. 41).

The importance of this notion of mathematical proficiency to this study is considerable as it gives a broad framework and language for describing learners' mathematical proficiency trajectories over the research period, using research question one. I look at this progression using the Mathematical Proficiency interview (Wright, Martland, Stafford, et al., 2006) and fluency instruments described in the Methodology chapter.

However, it should be noted that this view of mathematical proficiency does not consider social or cultural factors, nor does it describe how mathematical learning occurs. As such it was necessary to find a way to link the notion of mathematical proficiency as described above with the view mathematical learning presented in this chapter and it is to this that I now turn.

Linking the concept of mathematical (numeracy) proficiency with learning

Kilpatrick et al.'s (2001) mathematical proficiency framework is a comprehensive way of looking at *what* children need to learn in order to be mathematically proficient. "That means they understand mathematical ideas, compute fluently, solve problems, and engage in logical reasoning. They believe they can make sense out of mathematics and can use it to make sense out of things in their world. For them mathematics is personal and is important to their future" (p.409).

What it doesn't provide is an understanding of the learning process itself. Although Kilpatrick et al. (2001) specifically stated that they do not endorse a single approach to teaching and learning, there are some suggestions in their report that point to a particular way of teaching and learning. The full report gave five recommendations that reflect their vision for mathematics. With the dual nature of my study in mind, I highlight the first of these, which stated:

> *the integrated and balanced development of all five strands of mathematical proficiency should guide the teaching and learning of school mathematics. Instruction should* ***not be based on extreme positions that students learn, on the one hand, solely by internalizing what a teacher or book says or, on the other hand, solely by inventing mathematics on their own*** *[emphasis added] (p.410).*

Here we see alignment of the proficiency framework with the view of learning presented above. Their section entitled "*Managing Classroom Discourse*" points out that research supports the notion that mathematics classrooms are more likely to be places in which mathematical proficiency develops when they are "communities of learners and not collections of isolated individuals" (p.425). This points to a participationist perspective of learning that takes account of social factors in classrooms. With this notion as a backdrop, they recommend the following:

1. *A significant amount of class time should be spent in developing mathematical ideas and methods rather than only practicing skills.*
2. *Questioning and discussion should elicit students' thinking and solution strategies and should build on them, leading to greater clarity and precision.*

3. *Discourse should not be confined to answers only but should include discussion of connections to other problems, alternative representations and solution methods, the nature of justification and argumentation, and the like*
   (Kilpatrick et al., 2001, pp. 425–426).

This links to the view of learning presented above and the guiding principles for my work with club learners. The third point suggests that the discourse in the classroom is one that allows for individual and collective meaning making as well as ways of ensuring that learners get opportunities to test and validate their mathematical knowledge using justification and argumentation so that it becomes individually appropriated and collectively conventionalised. From a conceptual and theoretical point of view, the mathematical proficiency framework detailed above coheres well with the view of learning for both the club research and development aspects of this study.

Assessing mathematical proficiency

Since an aim was for learners in my research clubs to develop mathematical proficiency in each of these five strands, I needed a way of tracking and seeing how learners actually developed towards this fully elaborated notion of mathematical proficiency. The *Learning Framework in Number* (LFIN) developed by Wright and his colleagues (2006) provided me with a useful way of doing this. Wright et al. (2006) described the LFIN as providing a "blueprint for the assessment and indicates likely paths for children's learning" (p.7). This framework has been used to research and document progress in number learning of five to eight year old students in the first three years of schooling. As an intervention programme it involves intensive one-to-one teaching of low-attaining students but the programme has also been used with students of all levels of attainment (Bobis et al., 2005). The intervention programme known as 'Mathematics Recovery' (MR) (Wright, 2003) has been used extensively by school systems in several countries including Australia, Canada, the United States, the UK and Ireland (Wright, Martland, & Stafford, 2006).

Whilst MR has been used and tested in these other countries, it has not yet been implemented in a South African context. However, research in South Africa on the programme is beginning to grow, particularly by scholars working in the SA Numeracy Chairs at the University of the Witwatersrand and Rhodes University. For example, see the recent Masters Theses by Weitz (2012), Mofu (2013) and Ndongeni (2013). Due to the nature of our South African classrooms, it is not always possible to use such frameworks in a one-to-one setting and the power of the framework is thus difficult to use in our local context. My research and other local research aims to investigate how the framework could be used in South Africa and at the same time contribute to the body of MR literature with a South African perspective.

The MR programme is made up of *three* main components: the LFIN, the assessment interview and a teaching framework. In this study I used the LFIN and the assessment interview. I worked with a version of the LFIN that combines elements from Wright and colleagues 2006 and 2012 works. The key aspects of the LFIN are:

A. *Structuring numbers 1 to 20*
B. *Number words and numerals (including forward and backward sequences)*
C. *Conceptual place value knowledge (ability to reason in terms of tens and ones)*
D. *Early arithmetic strategies (strategies for counting and solving simple addition and subtraction tasks)*
E. *Early multiplication and division*
(Wright, Ellemor-Collins, & Tabor, 2012; Wright, Martland, Stafford, et al., 2006)

Each of the key aspects of the LFIN can be elaborated into a progression of up to six levels or stages. Each aspect has a model describing the characteristics of the levels or stages (Wright, Martland, Stafford, et al., 2006) which are detailed in Chapter 4.

The LFIN framework is a powerful tool for profiling an individual club learner's mathematical proficiency across the range of key aspects. Profiling of learners' mathematical proficiency in this way formed a basis for planning the club activities and mediatory interventions that were tailored to each learner's current levels of proficiency and strategies (Wright, 2003) using the Zone Theory club design framework. It also enabled monitoring of progression from one level (stage) to another, over time for the individual learner, thus providing data for research question one.

Additionally, the LFIN and the principles of Mathematics Recovery provided the basis for the orally administered one-to-one numeracy interview which I refer to as the Mathematical Proficiency (MP) interview (see Methodology chapter) as well as a way of structuring and reporting on data generated from these instruments for this research thesis, research articles and SANC project reports.

Finally, it is important to explain Wright et al.'s (2006) view of knowledge and learning so as to establish coherence between these and the broader theoretical perspective adopted for this study. Wright et al. (2006) state that they are "strongly constructivist" (p. 7) and hold the belief that "mathematical knowledge cannot be passed on to children" (p. 49). Their work is based on the principles that learning mathematics is an active process, each child constructs their own mathematical knowledge and that they develop mathematical concepts as they engage in sense-making, mathematical activity. Knowledge for them, encompasses skills and understandings. They do not distinguish between concepts and procedures as in their view, in early number learning, these are closely interrelated. Wright et al.'s (2006) MR programme is based on sense making and mathematical activity and normally takes place alongside a teacher or other adult. In this way learners are not working on their own discovering knowledge *per se* but are assisted by a more knowledgeable other. This coheres with the view of learning used by my study.

Fluency as part of mathematical proficiency

While the promotion of all five strands of mathematical proficiency is important, an aspect of focus in my case study clubs and the broader SANC project is the promotion of fluency. This focus is based on our experience in the South African context where concrete one-to-one methods of calculation dominate throughout the primary grades. I thus unpack the notion of fluency for my study and review related literature in the section below.

Literature review of fluency

Gojak (2012) stated that when asked what fluency in mathematics is, many educators would answer that it is simply speed and accuracy. Others would say that fluency is the mastery or rapid recall and retrieval of basic facts and computational skills. Kilpatrick et al. (2001, p. 121) defined *procedural fluency* as "knowledge of procedures, knowledge of when and how to use them appropriately, and skill in performing them flexibly, accurately, and efficiently". While Kilpatrick et al.'s (2001) definition focused on procedure and methods of calculation both mentally and with pencil and paper, Askew (2012a) on the other hand talked about fluency with respect to "elements of fluency" which include *basic facts* and knowing *basic methods* (2012a, p. 55). He listed these 'basic facts and methods' as:

- *adding or subtracting a single digit number to any number*

- *adding a multiple of 10 or 100 to any number*
- *counting on or back in 1s from any starting number*
- *counting on or back in 2s, 10s, or 5s from any starting number*
- *multiplying any number by 2 or 10*
- *multiplication facts up to 10 x 10*
  (2012a, p. 55)

Askew (2012a) argued that children are hampered if they are not fluent in knowing and using these basic facts and methods. He considered some additional elements to be "semi-fluent" in the "sense of knowing how to figure out the answer without a great deal of having to think through how to get there" (p.59). These included:

- *knowing what to add to a number to make it up to a multiple of 10 or 100*
- *halving any number*
- *multiplying any number by 5 (by multiplying by 10 and halving)*
  (Askew, 2012a, p. 59)

Askew (2012a) made a strong argument that "the point of being fluent in them [these facts and methods] is to free up working memory when tackling a more interesting and engaging piece of mathematics" (p.54) in much the same way as being able to touch type frees up working memory when writing, which allows one to think about the content rather than being preoccupied with how to type. He argued that lack of fluency in basic facts and methods can impede conceptual understanding because certain processes take up too much working memory and attention is diverted from thinking about the bigger mathematical picture. In this way fluency and conceptual understanding go hand in hand. This argument is supported by Pegg (2010) who asserted:

> *working memory is limited in capacity and duration. As we become more expert in a task, our working memory capacity does not increase but it does become more efficient. Improved automaticity in fundamental/basic skills, such as calculating, at lower levels frees up working memory resources for processing higher-order skills and understandings (p. 37).*

While there is a range of definitions for fluency, there seems to be consensus in the literature that fluency is more than being fast and accurate. Good practice will ensure that learning to be fluent should be intertwined and developed along with sense making and flexible thinking (Askew, 2012a; Boaler, 2012; Bobis, 2007; Burns, 2007). This is the notion of fluency that I adopted for this study and used to design my data collection instruments. This consensus coheres with Kilpatrick et al.'s (2001) recommendation that the strands of mathematical proficiency be taught using an interwoven approach.

The argument for developing fluency in basic facts is strong but many agree that it must be grounded in understanding. It seemed worthwhile then that one of the many focus areas for the clubs should be on developing fluency in the club learners within the broader notion of mathematical proficiency.

I now turn to review the theoretical framework for research question two.

2.5.2 THEORETICAL PERSPECTIVE INFORMING RESEARCH QUESTION TWO

Research question two: What is the nature of the mediation that enables or constrains the emergence of a ZPD in the club learners?

Returning to Simon's (2009) idea of what we look *with* and *at*, for this question I looked *with* a social-cultural perspective at *participationist* aspects between learners and mentors in the social context of the clubs. This question was concerned with explaining *what enabled* mathematical progress and with the *nature of the mediation* that enabled or supported this mathematical learning progression whilst learners participated in clubs. In this sense the lens or gaze was much wider than for question one in that it looked at aspects of participation, interaction and associated social factors. The data collection for this question included video and audio recordings as well as journal reflections. As such, rich, qualitative data was gathered with which to examine the nature of learning in a club with a foregrounded participationist perspective.

As a result, my explanatory and analytic frameworks needed to zoom out to be wider than an individual learner. I discuss in more detail the concepts inherent in the question itself (mediation and the ZPD) and expand on how I used these to answer this question.

How the ZPD is used for answering question two

Following the earlier discussion in Section 2.3, the notion of the ZPD adopted for this study is based on the following assumptions and is considered to align with the interpretations of the ZPD that support a deeper understanding of the ZPD in context in terms of the participants, their interaction, collaboration and activity, the types of tools used, the type of mediation used and the cultural-historical context (following Levykh, 2008). Thus my interpretation favours the ZPD as a symbolic space that encompasses the whole person. The emergence of a ZPD is enabled by presenting activities that are meaningful to the learner, activities that can be accomplished with assistance, ones that allow the learner agency to benefit and take advantage of the assistance from others. The learning activity is the focus for analysis and includes the task, the ethos of the club and the possible ways that the participants may interact in that moment.

The story of how the ZPD emerged as a key analytical tool in the pilot is explained in Chapter Three when I discuss the pilot club.

The ZPD as an analytic tool

Methodologically, the Vygotskian orientation calls for a focus on what is said, written, gestured and otherwise presented by the participants in the club and as suggested by Meira and Lerman (2009) I focus on the learning activity in my analysis. The learning activity encompasses the actual task, the club ethos and the possibilities that arise out of the interactions between the mix of participants on the day of the task-based interviews. My analytical framework therefore needed to take these foci into account. Roth and Radford (2010) encouraged researchers using the ZPD as an analysis tool to look at them not only as zones of agreements but also of tensions, disagreements, misunderstandings, conflict, and subversion.

Our pilot data revealed that ZPDs were created in lots of different ways in the clubs, based on the types of activities the learners were involved with. These ZPDs included or pointed to many of the different conceptualisations that I have discussed in the sections above. However, for this study, my focus was on looking at the forms of mediation that allowed a ZPD to emerge for club learners.

A primary form of mediation commonly associated with the ZPD is that of *scaffolding*. The section below gives a brief overview of the notion of scaffolding in mathematics education. I then elaborate how and why the notion of scaffolding became an important part of this study and define the notion for my purposes. Finally, I sketch the outline of the analysis framework, which is detailed further in the Methodology chapter.

Scaffolding

From experiences with both the pilot club in 2011 and viewing of the video data in the task-based interviews from my research clubs in 2012, scaffolding of learners by myself and fellow mentors during club activities was particularly visible. As such, I was interested to find out what the nature of this scaffolding was. Were the techniques we were using effective in enabling learners to think about mathematics at a deeper or more conceptual level or were we simply leading the learners through steps? This led me to review research that explored the use of scaffolding specifically within the ZPD construct, and research that extended the traditional notion to examining scaffolding practices that gave learners access to more conceptual support in mathematics.

It is generally accepted that the metaphor of scaffolding was introduced by Wood, Bruner, and Ross (1976) to describe the tutorial process where an adult or ‘expert’ helps somebody who is less ‘expert’ or not an adult to perform tasks that they cannot do alone. Although the metaphor was originally used in a “pragmatic and atheoretical” manner (Stone, 1998 p. 345) the notion of the zone of proximal development soon became linked with Vygotsky’s developmental theory (Stone, 1998; Wertsch, 1984; Wood et al., 1976). Stone (1998) argued that initial uses of the metaphor of scaffolding relied on literal notions of internalisation of the interchange between child and adult. This initial notion would then be at odds with my theoretical orientation for this study.

In the 1980s and 1990s, a second-generation of interpretations emerged based on the emerging sociocultural framework which derived from more detailed engagement with Vygotsky’s work (Goos, 2004). Moll (1990) explained that these second-generation interpretations began to stress the importance of collaboration, enhancement and communication of meaning and sense making in scaffolding rather then seeing it as a means of transfer of skills or knowledge. These were thus more in line with Vygotskian theory. The teacher’s role was therefore re-conceptualised from being in charge and presenting learning to one that uses communicative acts to support learners in making sense of their mathematics learning.

Twenty years after its initial conception Bliss, Askew and Macrae (1996) revisited the notion of scaffolding. They concluded that the concepts of scaffolding and the ZPD had become important guiding ideas in education. However, they argued that “research focusing on the nature of scaffolds and their functions in specific schooling contexts” (p.38) was still limited. Stone's (1998) thoughtful review of the metaphor gives a brief history of its use in education and presents five major concerns or criticisms of the metaphor as raised by others. Meira and Lerman (2001) argued that early notion invited the teacher to "analyse the concept/activity in advance" and bring that prior analysis to the learning situation. They believed that this conceptualisation ignores what constitutes the learning activity in that it ignores the sense that the child makes of an activity; the meanings and experience that the child brings to the activity; the dual engagement of teacher and leaner in the activity; the learning which the teacher undergoes and the class of semiotic devices that are used for communication in the classroom (p. 203).

In spite of its limitations and many criticisms, over 25 years later the notion is still evident and indeed popular in mathematical research literature (Anghileri, 2006; Verenikina, 2008). There is an "enduring attraction" (Anghileri, 2006) in the "way it emphasises the intent to support a sound foundation with increasing independence for the learner as understanding becomes more secure" (p.33). However, following Stone (1998), Verenikina (2008) considered that to fulfil the expectations of scaffolding being an effective teaching tool, there is a need for a better, critical understanding of the nature of scaffolding based on a broader awareness of its theoretical underpinnings. She believed that this will "promote its creative and informed use by educators" (p. 13).

What is evident in the literature is a move away from literal interpretations of a "construction scaffold" (Stone, 1998, p. 354) towards a notion that is more complex, more flexible and includes communicational exchanges and which engage the learner actively in the teaching and learning process. This is evident in the interaction patterns described by Siemon and Virgona (2002, 2003) as *scaffolding practices*. They introduced the idea that each practice has a different level of teacher support and learner independence. For example, they showed *modelling* as having high teacher support and low student independence. Their practices, as adopted by the Victoria Department of Education and Early Childhood Development (2004) were sorted into 12 major categories such as excavating, modelling and so on. Each category was described and showed a list of practices that were synonymous with that category. In 'excavating' for example, other practices listed are: drawing out; digging; uncovering what is known and so on. This list provided educators with a common language to talk about the kind of practices in their classrooms. I found the list useful for the range of descriptive words used for different types of scaffolding and referred to it extensively during the early analysis of my video data.

As these scaffolding practices were presented in a non-hierarchical way, the list did not sit well with the underlying theory of development and learning adopted for this study, as it did not differentiate between which practices might be more effective or those that might lead to developing higher conceptual levels of thinking in learners. One aspect of the literature on scaffolding revealed that some educators were talking about the nature of the guidance and the quality of the interactions in scaffolding situations (see for example Kozulin & Gindis, 2007; Stone, 1998; Verenikina, 2008).

These ideas resonated with my own thinking about the nature of our mediation or scaffolding in the clubs. Anghileri's (2006) work further resonated with me as not only did it extend the conceptualisation and understanding of scaffolding substantially but it also related specifically to the mathematics classroom and teaching. She pointed out that current trends in learning suggest that effective teachers will use a *range* of teaching approaches that encourage active involvement in learning. She brought together scaffolding strategies from a range of previous studies and introduced some additional ones. She proposed a range of scaffolding practices that can be used in teaching and showed which are the most frequently used as well as those that are potentially the most effective or strongest scaffolding practices in mathematics teaching. She proposed "three levels for scaffolding" which are presented in the form of a hierarchical model of observed patterns of interaction (Anghileri, 2006, p.39). The three levels are discussed briefly below and in more detail in Chapter 4.

- *Level 1 practices: Environmental provisions.* Learning can take place through interactions with various environmental provisions but do not involve direct interactions between the teacher and students (e.g. classroom organisation, artefacts, self corrected tasks etc.). These environmental provisions are not always seen as scaffolding practices.
- *Level 2 practices: Explaining, reviewing and restructuring.* These involve direct interactions between the teacher and students and are related specifically to the mathematics under consideration. Traditional scaffolding practices tend to be evident at this level.

- *Level 3 practices: Developing conceptual thinking.* This level consists of interactions that *explicitly* address the development of conceptual thinking in students and which she observes are often lacking in classroom interactions.

These levels encompass the full range of scaffolding practices that can be used in mathematics teaching and for me this hierarchy provided space for introducing interactions that enrich and extend mathematical practices into the classroom. I saw that this hierarchy or model could usefully be used to provide an analysis framework for research question two, particularly in analysis of the video data from the task-based interviews. This model is replicated in detail and discussed further in the Methodology chapter.

Anghileri (2006) concluded that what is needed is perhaps the notion of a “flexible and moving scaffold (that allows for individual creativity) in which teachers are responsive to individuals even within the classroom setting ... The goal in teaching is for autonomous and independent, self-motivated learners. For this purpose, flexible and dynamic scaffolding will need to be responsive to the emerging learner within the social group” (p.51). These perspectives suggested that teachers must rethink the ways in which they scaffold learning opportunities (Bell & Pape, 2012) and were useful for me as both mentor and club programme designer and as an analysis tool.

Following Anghileri (2006), the notion of scaffolding adopted for my study refers to the ways in which myself (and fellow mentor, Mellony Graven) created the learning environment in the clubs and took action to help students learn (construct, deepen, solidify, and consolidate learning). Learning in the ZPD and using the mediating means of scaffolding includes setting up the physical and social structures for engagement, providing challenges and responsive support, and developing conceptual thinking (Anghileri, 2006). This resonates with the ZFM and ZPA constructs which are used for the club design. The nature of the scaffolding in clubs and whether or not it is a creative, flexible notion will be discovered through analysis of the data collected for research question two. For my study, scaffolding is a mediating practice or means that enabled me to examine how ZPDs emerged in club learners.

Catching attention and modes of social interaction

Following the pilot, my decision to use the ZPD as an analytic tool led me to read more deeply on how to do this. I realised when viewing the video data collected for research question two (using the task-based interviews) that I would need to have a clear way of analysing how ZPDs emerged for the club learners and what enabled or constrained the emergence of the ZPDs. I was specifically drawn to Meira and Lerman's (2009) suggestion that the emergence of a ZPD is dependent on whether the participants in a learning activity catch the attention of the other(s) as this was something I had observed during club sessions in the pilot. They argued that when someone or something captures a learner's attention their subsequent utterances and actions could be modified, creating a scenario where a ZPD might emerge. In a private conversation with Steve Lerman[10], he spoke about how, once the attention is caught, it may or may not be sustained. The sustaining of attention amongst participants allows for the possible emergence of a ZPD. In Lerman's response to Goos (2012), he asks:

> *what sense can we make of the catching of attention in 'individuals negotiating their relationship with the learning environment and the people in it'? (Lerman, 2012, unpaged)*

This idea of making sense of how attention is caught resonated with me and I realised that this may be a way to determine if a ZPD was created during interactions in my task-based interviews. What was not clear, particularly from Meira and Lerman's work, is *exactly how* attention is caught. In his work, Lerman (2001) talks of looking for clues about the nature of communication between participants and for instances where utterances or actions affect another and result in a modification of what they say or do. I hope to explore this further in the analysis of data for research question two and make sense of how this affects the emergence of a ZPD.

With regard to the nature of communication, Roth and Radford (2010) urged researchers to investigate the "discursive, corporeal and other actions" (p. 306) that participants use to interact and relate to each other in learning and teaching contexts. This is often referred to as multimodality, which extends a social interpretation to a range of representational and communicational modes such as gesture, gaze, movement, and posture (Bourne & Jewitt, 2003; Radford, Edwards, & Arzarello, 2009; Roth, 2001). Bourne and Jewitt (2003) argued that all modes of communication like language, have been shaped through their "cultural,

[10] Prof Lerman is an advisor for my PhD. In 2013, we worked through some of the analytical issues I had with my video data for research question two.

historical, and social usage" (p. 65). For example, Radford, Edwards and Arzarello (2009) argued that gesture "acts in the generation as well as the communication of meaning (p. 93) in mathematics. Whilst this aspect of communication is an important high-level indicator for my study, I do not specifically focus on the role of gestures and other modes in learning. I do however use these modes of communication to understand the interactions used by participants when communicating mathematical ideas to each other. This analysis acted as a precursor to the more important focus on catching attention.

2.5.3 SECTION 2.5 CLOSING REMARKS

In this section, I have reviewed the theoretical frameworks, constructs and concepts that are fundamental to each of my research questions and indicated why and how I have adopted them for my study.

For research question one, I have reviewed and discussed mathematical proficiency, assessment of mathematical proficiency and fluency, indicating how they relate to the study. For research question two, I have detailed my specific view of the ZPD for this study and have reviewed mediation (scaffolding) and attention catching mechanisms, indicating why these are important to the study.

2.6 CHAPTER TWO: SYNTHESIS AND SUMMARY

I have described the journey that I have taken in terms of arriving at the complementary choice of lenses for analysis, which have a different emphasis for each question. I have positioned myself within my theoretical frameworks and have established coherence between meta-theory, learning, club design, mathematical proficiency and analytic tools. I have also exemplified how the dual notions of acquisition and participation are interwoven in my study. Below, I summarise the constructs defined in this chapter for ease of reference in subsequent chapters. These definitions also appear in the Glossary at the end of this thesis.

Summary of concepts and constructs for this study

Figure 5 on page 83 provides a visual summary[11] of the constructs showing how they relate to the study as a whole and how they connect to each other. In summary:

- *Learning and development* are a dialectical unity in which learning leads development. Learning cannot exist without development and development cannot exist without learning. The process of development is not a direct and natural process, but rather indirect, mediated by cultural laws of teaching and learning. Learning awakens a variety of internal development processes that are able to operate only when the child is interacting with people in his environment and in cooperation with his peers. Learning is a necessary and universal aspect of the process of developing culturally organised, specifically human, psychological functions.
- *Mediation* is a form of intervention that focuses on experiences during the process of thinking and learning and refers to use of cultural tools (or signs) to bring about qualitative changes in thinking.
- *ZPD*. My articulated notion of the ZPD indicates that a ZPD does not exist prior to the learning activity and is created (or not) through the social interactions with others during club activities. It depends on the active contributions of the learners as well as the mentor. The ZPD is as a symbolic space that encompasses the whole person. The emergence of a ZPD is encouraged by presenting activities that are meaningful to the

[11] During the course of writing this chapter, I compiled a mind map of the constructs for this study and how they relate to each other. This is included in Appendix K

learner, activities that can be accomplished with assistance, ones that allow the learner agency to benefit and take advantage of the assistance from others. The learning activity is the focus for analysis and includes the task, the ethos of the club and the possible ways that the participants may interact in that moment.

- *Zone Theory.* Used as a design framework for the clubs (empirical field for this study) and as an explanatory tool, Zone Theory describes the structure of the developing club learners' environment and the relationships between the learner and the other people in the environment. It assists with a better understanding of how the ZPD operates in a specific learning context and creates a picture of the physical and cultural space in which the ZPD is situated. The zones are dynamic, interrelated constructs which interactively generate the environment in which the learner develops.
- *Scaffolding* refers to the ways in which mentors create the learning environment in the club and take action to help students learn (construct, deepen, solidify, and consolidate learning). Learning in the ZPD and using the mediating means of scaffolding includes setting up the physical and social structures for engagement, providing challenges and responsive support, and developing conceptual thinking (Anghileri 2006).
- *Mathematical proficiency* is the ability to process, communicate and interpret numerical information in a variety of contexts (Askew et al., 1997) overlaid with strands of numeracy proficiency (Kilpatrick et al., 2001): understanding numeracy concepts, computing fluently (practically, mentally and procedurally), applying concepts to solve problems (in creative and inventive ways), reasoning logically (in creative and inventive ways) and engaging with mathematics – seeing it as sensible, useful and do-able (enjoyment and passion) (Graven, 2011c).
- *Elements of fluency* include basic facts and knowing basic methods. Learning to be fluent should be intertwined and developed along with sense making and flexible thinking and should be taught using an interwoven approach.

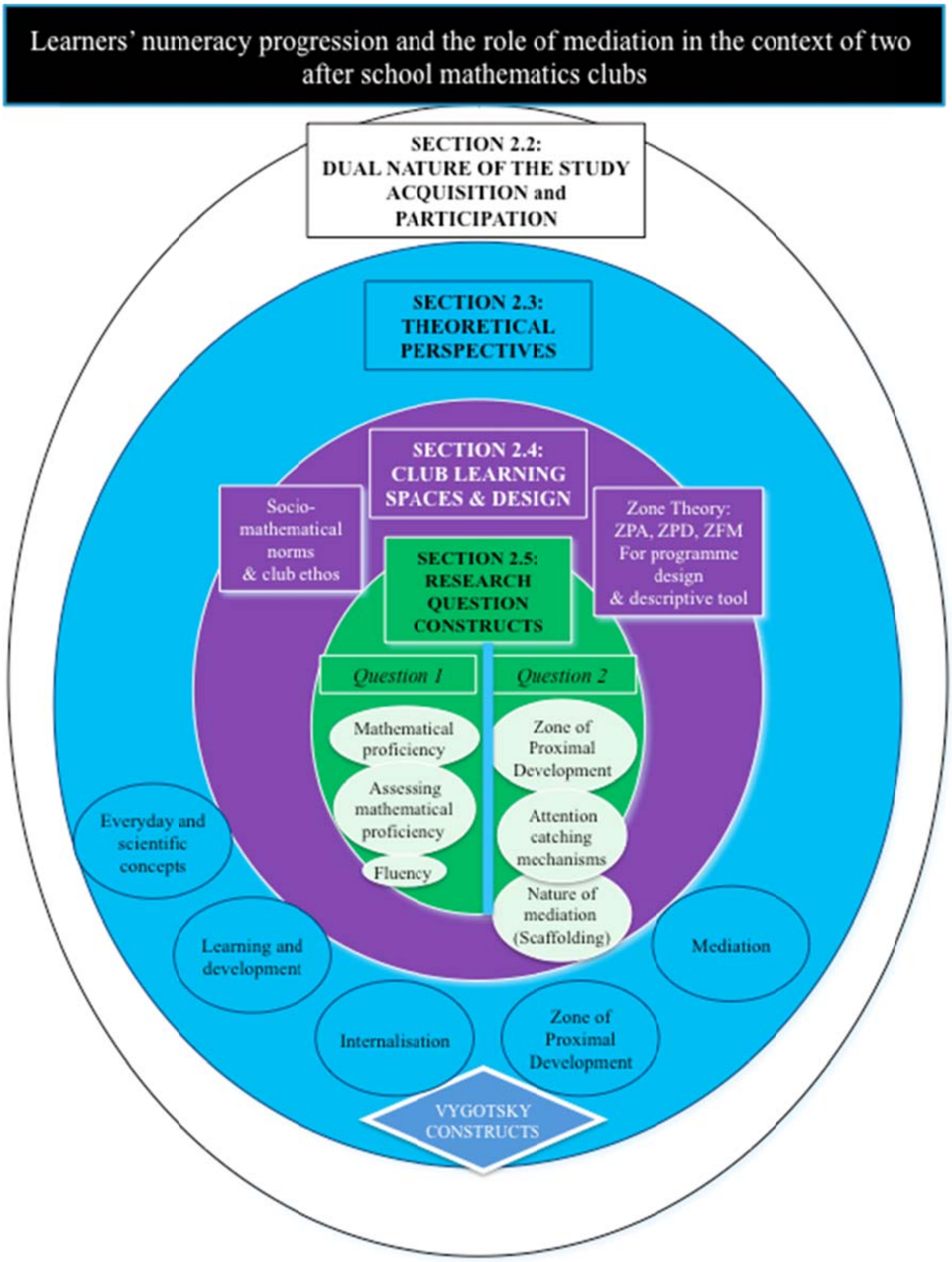


Figure 5: Visual summary of constructs for this study

---- END OF CHAPTER TWO ----

CHAPTER 3
AFTER SCHOOL CLUBS: THE EMPIRICAL FIELD

3.1 INTRODUCTION AND CHAPTER OUTLINE

In this chapter I detail the empirical field for my study. The chapter is divided into five sections as follows:

Section 3.2

In this section I explain the context in which the empirical field is situated and my role in that context.

Section 3.3

In this section I share how the pilot club influenced my work in the research case study clubs. The insights from the pilot club in 2011 and the lessons learnt are fundamental to how the research clubs were set up and designed in 2012. For this reason these lessons are presented in this chapter.

Section 3.4

In 2012 two case study research clubs were set up. In this section I give a brief overview of the design framework used for the design of these clubs.

Section 3.5

The two clubs that form the empirical field for this study are described in this section.

Section 3.6

Closing remarks for the chapter.

3.2 THE SANC PROJECT CONTEXT AND MY ROLE IN THAT CONTEXT

In response to national poor performance of learners in numeracy in South Africa (Bloch, 2009; Fleisch, 2008; Taylor et al., 2008), research and development funding organisations have begun to invest in projects that focus on early mathematics (or numeracy). My work within one such project (the SANC project) is focussed on both development and research in the field of numeracy and is funded by the FirstRand Foundation (with the RMB), Anglo American Chairman’s fund, Department of Science and Technology and the National Research Foundation. In development terms the SANC project aims to improve the quality of teaching of in-service teachers at primary level and to improve learner performance in primary schools as a result of quality teaching and learning. The research remit is to grow an area of research which looks towards finding sustainable solutions to the many numeracy education challenges faced in our area.

As part of the developmental work, the SANC project began in 2011 and has worked with 14 schools in the greater Grahamstown area, Eastern Cape, South Africa. The NICLE teacher development programme has worked with approximately 45 numeracy teachers (ranging from Grade 0 to 6) since the project started. These teachers have participated in regular workshops focused on issues and challenges in numeracy teaching.

As well as teacher development, learner activities are a key part of the SANC project developmental activities and are a context where we work *directly* with the learners in our project schools. By running learner-directed and learner-oriented mathematics activities as well as creating an ethos of ‘mathematics is fun’ in schools we facilitate the development of learner mathematical proficiency. Many teachers find themselves faced with the challenge that most of their learners do not have the necessary mathematical foundations to be learning at the grade level in which they are placed. As a possible way to address some of these challenges, the SANC project decided to implement after school mathematics clubs as a more focussed and regular learner intervention (Graven, 2011c, 2012b). Within the SANC project, the clubs serve two purposes: firstly, they are a place where we can directly influence what happens with learners and secondly, they provide us with an empirical research field in which we can interact directly with the learners and thus be insiders to the learning process.

3.3 PILOT CLUB: OVERVIEW AND INFLUENCE ON RESEARCH CLUBS

Guided by the practices we wished to promote in the clubs (see Table 1 in Chapter One), Mellony Graven and I went into the pilot club with a grounded approach and open minds to how we would structure the club. I had done some reading on the adapted version of Zone Theory design framework as suggested by Goos et al. (2007a) but this was merely a guiding tool.

We chose a school participating in the NICLE teacher development programme that was close to the university and where we had a good relationship with the principal. We visited her to explain our idea for the club and she was eager for us to pilot it in her school. She discussed the idea with the Grade 3 class teacher and the class teacher selected 10 learners (7 females and 3 males) to be in the club. Parental consent letters were obtained for all learners. The club started on 24th August 2011 and took place every Wednesday during term time for an hour after school. We had a total of 14 club sessions.

Whilst the language of teaching and learning at the school is English, the majority of the learners in the club spoke isiXhosa. As this was the pilot club, both Mellony Graven and I co-mentored the club. As such, I shall use the word ‘we’ in the paragraphs below where appropriate as both of us were involved in the process of mentoring, reflecting on club sessions and evaluating the club programme over the course of four months.

In the first few club sessions, we established the club norms as described in Chapters One and Two. We also established some ground rules with regard to listening to each other’s ideas, no fighting, emotional bullying or laughing at each other’s contributions. It was revealing that when we indicated that they could be messy in their rough work, the learners were initially reluctant to do this. Mellony took a piece of paper and scribbled on it and then encouraged the learners to do the same thing. They then joined in with gusto!

As part of the club ethos, we tried a number of initiatives that encouraged the learners to do mathematics at home. In the first club session, after playing a dice game, we gave the learners two dice to take home to encourage the learners to play games and practice mathematics at home. We asked the learners to share what they had learnt in the club or teach the game to someone else. This idea developed into what we called the “Pay-it-forward” concept.

Influence of the pilot club on the research study

The pilot club influenced this research study in *three* key ways. Firstly, it influenced the design of the learning programme for the two case study clubs (the empirical field). Secondly, it influenced subsequent data collection and finally it revealed the ZPD as an analytic tool for the study. I expand on each of these.

1: Influence on design of the learning programme for the case study clubs

The pilot study suggested that learners enjoyed the opportunity to take books home and to engage with siblings and parents in working in the books. While we initially suggested to our learners that they do a page a day, to our surprise and delight, most learners completed the first workbook (48 pages) within the first week indicating a thirst for take home activities. We decided to continue to promote this activity in subsequent 2012 clubs.

We observed in the pilot club that card, dice and other games were an excellent way to encourage learners to practice their mathematics informally or through ‘play’ at home. Additional sites of learning are often taken for granted in middle class families where card and dice games are part of children’s lives. This idea was carried forward into 2012. Short games, particularly those played with dice, are easily accessible to younger learners and can aid in the development of core number skills, mental agility and fluency in number. Other benefits of using games include motivation, developing positive attitudes towards mathematics and allowing children to operate at different levels of thinking. In playing these games in the pilot club, we found that the learners began to strategise in games that required this skill and to build fluency in basic number facts. Games also enabled club learners to engage in mathematical activities in different ways and to build confidence by doing so. They also contributed to the ‘maths is fun’ ethos we promoted and were something that the learners could take home to teach other family members. As such, games became part of the promoted activities of my case study research clubs and other SANC project clubs in 2012.

2: Influence of pilot on data collection

The timely administration of diagnostic assessment tasks in the pilot club enabled a powerful data-driven approach to club activity selection to emerge for the pilot. I drew on the Askew et al. (1997) instrument which I orally administered to the whole club. Learners recorded their answers on individual scripts.

However, I struggled with a way to track learners' on-going progress in mathematical proficiency with the instrument as it stood. Administering it to the whole group simultaneously allowed me to see if a learner had answered a question correctly but this method gave me little as to *how* they had answered the question and whether the methods they used to arrive at an answer were *efficient*. Following this I decided to draw on the one-to-one interview (as a data collection instrument) and the Learning Framework in Number (as an analysis framework) from the Wright et al. (2006) Maths Recovery programme for the case study clubs. As discussed in Section 2.5 of Chapter Two, this interview and the LFIN gave me the option of administering detailed one-to-one interviews with club learners and noting how they arrived at various answers, profiling learners at particular stages / levels in the LFIN and tracking detailed progression over time, thereby providing data for addressing research question one.

In addition, in the pilot, we introduced a series of timed fluency activities to encourage learner fluency in basic facts (drawing on Askew's (2012) basic facts discussed in Chapter Two). Initially, these activities were intended to simply be part of the mental maths warm-up activities promoted. However we realised that they provided useful research data for monitoring learner progression, particularly in terms of fluency. A clear advantage of these activities was that they took roughly ten minutes to administer, giving us quick access to learners' fluency levels in the basic facts. I thus decided to give them to my case study club learners in 2012 on a more regular basis as a way of supplementing data collection and for quick evaluation of learners' progress. I report on their structure and effectiveness later in this thesis.

While we had not anticipated the significance of our post-club *reflections* these became the key drivers for planning each subsequent session and re-planning and refining the data collection and provided one of our key sources of rich learner data. These in-depth discussions took place between Mellony Graven and myself every week directly following each club session and lasted about half an hour. Detailed notes and sometimes recordings were made of what we discussed. These rapidly became a fundamental part of the on-going design, entwining both the data collection and design processes. They thus became an integral part of the data collection process from there on and provided a significant input for subsequent session design. Post session reflections enabled us to write stories about learners' progress in ways that took into account the interaction between the three zones

(ZFM, ZPA and ZPD). I thus included post session reflections as a key data collection method for my case study clubs in the form of a personal research journal.

3: Emergence of the ZPD as a key design construct from the pilot

Before the pilot, the ZPD (as part of Zone Theory) was one of three equal elements of the initial design approach, which also included the ZPA and the ZFM as discussed in Chapter Two. Following Goos's (2006) example, the ZPD was characterised as "a set of possibilities for development that are in the process of becoming actualised as individuals negotiate their relationship with the learning environment and the people in it" (p. 103). The ZPD construct was a way of recognising the status of learners' existing learning. An initial assumption here was that learners brought their *potential* ZPD with them into club sessions. However, what we saw during the pilot was a ZPD that was much more *fluid* and less of a fixed set of pre-determined possibilities. It seemed to be largely determined by how the learners interacted with each activity. Additionally, what they brought to each activity was clearly dependent on a whole range of social, emotional, health and other interactional influences.

I illustrate this fluidity with two examples. We noticed that one of the club learner's energy levels and health affected how she interacted and what kind of ZPD emerged for her in any given session. When her energy levels were high, she was focused, engaged, participated in club talk and made great strides in developing more efficient, non-concrete methods of calculating. At these times an expanded ZPD emerged for her. On another occasion, when by her own admission she was feeling unwell, we could see that she reverted to her trusted finger counting strategy for working out problems. She engaged with the activities in a far more restricted way than she had previously and didn't involve herself in mathematical talk. A limited and constrained ZPD emerged in the club for her that day.

Another learner, was usually quiet during sessions and did not contribute verbally to ideas or explanations. However, one day the boy he always sat with was absent and on that day his participation was different. He contributed to discussions and talked confidently to his partner during activities. For him that day, an expanded ZPD emerged in his interactions with his peers and us. Interestingly, he continued this more active participation in subsequent sessions.

These examples pointed me to a broader concept of the ZPD as a space that is generated and influenced by a range of factors including emotional and physical factors, interactional aspects and group dynamics and the nature of the activities promoted in the clubs. Below I provide a summary of key literature that enabled and supported my broader concept of the ZPD for my case study club.

Conceptualising the ZPD based on pilot experiences and literature reviewed

Our observations resonated with the work of other researchers conceptualising the ZPD in a similar way such as Meira and Lerman (2001, 2009), Radford (2010a) and Roth and Radford (2010). As discussed in Chapter Two, Meira and Lerman (2001, 2009) conceptualised the ZPD as a symbolic space involving “individuals, their practices and the circumstances of their activity” (2001, p. 217) and that learners can be “pulled into their zpds by a combination of the activity, the actors, and appropriate communication” (Lerman, 2001, p. 103). This idea of pulling a learner into a ZPD by a combination of factors (activity, actors and communication) indeed surfaced from our own observations. Another aspect of Meira and Lerman’s (2001) work that echoed our experience was the notion of the ZPD where the zones emerge (or not) in the activity as a result of different ways of participating and communicating in the classroom. They also pointed out that the ZPD is not a generalised, context-free notion (Meira & Lerman, 2009, p. 203). This reasoning led me to focus on Meira and Lerman’s (2001, 2009) work for exploring learning in the case study clubs.

Furthermore, Levykh’s (2008) work also resonated with our experiences of working with the pilot club learners. He drew attention to the affective aspects of the ZPD. Whilst aligning with Meira and Lerman’s work he further highlighted the ZPD as reflecting “constant changes in the emotional connections” (p. 91) amongst the participants.

Based on our observations, a number of key ideas surfaced for us from reviewing this selection of conceptualisations of the ZPD. I now summarise the re-conceptualised ZPD construct based on these experiences. As indicated at the end of Chapter Two, these can be summarised as follows:

A ZPD does not exist prior to the learning activity and is created (or not) through the social interactions with others during club activities. It emerges based on the active contributions of the learners as well as the mentor. The ZPD as a symbolic space encompasses the whole person. The emergence of a ZPD is encouraged by presenting activities that are meaningful to the learner, activities that can be accomplished with assistance, ones that allow the learner agency to benefit and take advantage of the assistance from others. The learning activity is the focus for analysis and includes the task, the ethos of the club and the possible ways that the participants may interact in that moment.

This definition of the ZPD was more suited to what we observed in the pilot club and therefore had an influence on how it was portrayed in the view of Zone Theory used in this study. With regards to my research, after the pilot, the ZPD emerged as a key focal construct for both my data analysis and club design as illustrated in Figure 6 below and was thus foregrounded over the ZFM and ZPA.

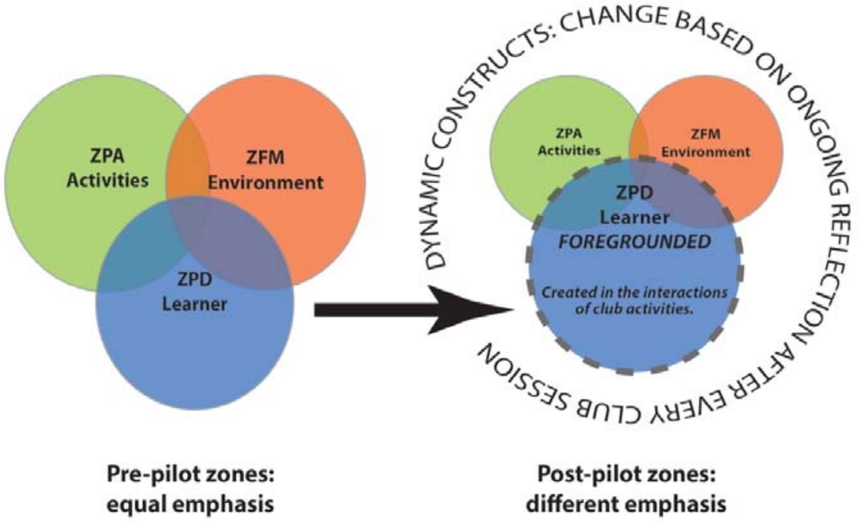


Figure 6: Pre and post pilot zone emphasis

In the next section, I give an overview of the design of the club learning programme framework used for the research clubs.

3.4 TWO CASE STUDY RESEARCH CLUBS: OVERVIEW OF CLUB DESIGN PROGRAMME

Following the discussion of lessons learnt from the pilot I present the design framework used for my two case study research clubs. Figure 7 below shows the design framework. Areas of the diagram are numbered 1 to 3 and are explained further below.

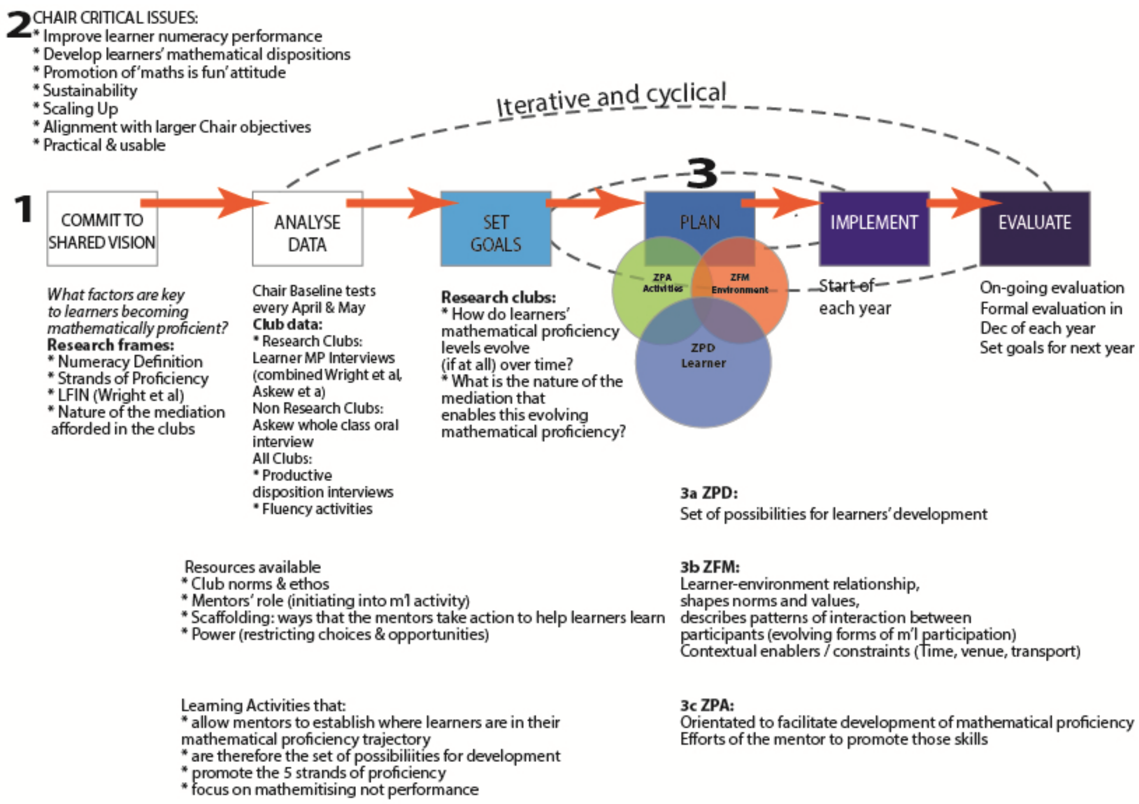


Figure 7: Post pilot club design

The aims of the SANC project are an integral part of the design and include the core research frames for the broader project. The design process reflects the inputs from the various zone elements as well as details pertinent to my study and the broader SANC project context (see 1). The critical issues that contribute to the programme are noted on the diagram (see 2).

For each club I considered the inter-related components of Zone Theory in terms of designing the learning environment and the activities that were promoted in the clubs to encourage learning to take place with the ZPD. In essence, for my study, the zones describe the structure of the learning environment in the club (or the physical and cultural space) and the relationships between the people in the club (i.e. myself as mentor and the learners).

Based on the conceptualisation of the Zone of Proximal Development (see 3a) described above, it is not possible to portray the ZPD as a fixed entity or as a fixed set of possibilities that are the same for each learner in the research clubs. Using the diagnostic assessment activities at the beginning of a club helped me to establish what the set of possibilities may be but these possibilities could only be developed in subsequent club sessions. The ZPD is created (or not) by the social and dialogical interactions of each club session and as such is different for every child, in every session. Therefore, the notion of the ZPD can only be explored by looking at the actual interactions that took place between the club participants during club sessions. This is the focus of research question two and is examined in detail in Chapter Six.

The *Zone of Free Movement (ZFM)* (see 3b) describes the learner-environment relationship and how that environment supports the intended learning, thus playing a supporting role in the emergence of the ZPD. Since the pilot this design construct remains unchanged. However the socio-mathematical norms that structure the environment (see Chapter 2) are clearer than before the pilot club. My role as mentor was to initiate the learners into these practices but without exhibiting power or authority. Therefore, it was important not to position myself as the teacher 'who has all the answers' nor as the person who has the power to say if something is right or wrong. Rather when asked if something was right, it was my practice to always turn the question back to the group to decide what they thought and if they agreed or disagreed.

The *Zone of Promoted Action (ZPA)* (see 3c) describes the activities that were promoted in the club to facilitate development of mathematical proficiency and the efforts of the mentor to promote those skills. It describes the diagnostic activities that allowed me to establish where learners were in their mathematical proficiency trajectories and activities that promoted the development of the five strands of proficiency.

This design framework addressed and accommodated the relationship between the acquisition and participation metaphors (Sfard, 1998) discussed in Chapter Two. Figure 8 shows my interpretation of Sfard's (1998) metaphorical mappings in the club design context.

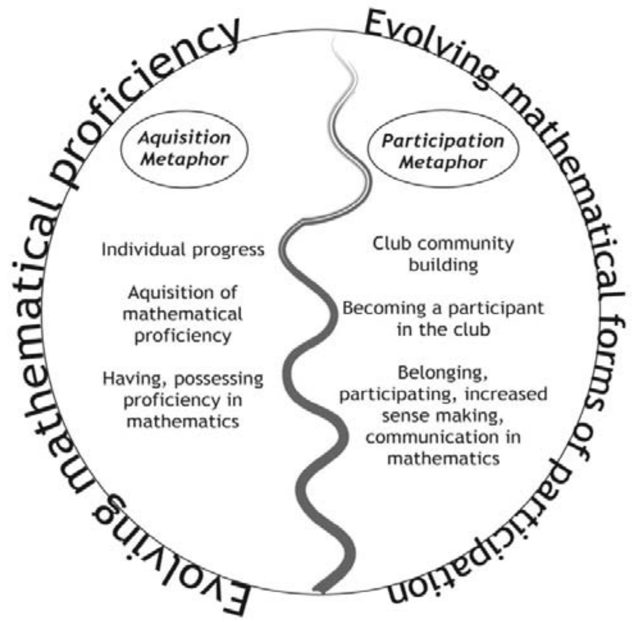


Figure 8: Club learning programme design: metaphorical mappings (adapted from Sfard, 1998 p.7)

The left side of the figure shows a focus on *individual* learner progress and the *acquisition* of mathematical proficiency. The right side highlights an intended focus on evolving forms of *mathematical participation* whereby the learners, myself and other people in the club become participants in the club with increased sense making and communication in mathematics.

The ZPD became a foregrounded construct that focussed on each individual club learner. The re-focussed diagnostic assessment activities (promoted in the ZPA) allowed me to establish and track where each individual learner was on their own individual mathematical proficiency trajectory, with the overarching aim of improving learner mathematical proficiency, thereby addressing the acquisition side of the design. On the other hand, participationist aspects were addressed through the ZFM construct which sets up the social and cultural aspects of the clubs, club community building, becoming a participant in the club and a sense of belonging for all participants. The collaborative activities promoted in the ZPA extend the participationist aspect further by promoting activities that allow possible increased sense making and communication in mathematics in a collaborative way.

3.5 TWO CASE STUDY RESEARCH CLUBS: DESCRIPTION OF THE EMPIRICAL FIELD

Using the Zone Theory framework explained in section 3.4 above, I describe the two case study clubs for this research study.

3.5.1 ZONE OF FREE MOVEMENT: SCHOOL AND PHYSICAL ENVIRONMENT

The ZFM describes the learner-environment relationship and how that environment supports the intended learning. In this section I look at the specific school and physical environment as these enable and constrain the ZFM for each club. I also look at the resources available.

Elmtree Prep

Elmtree Prep participated in the NICLE teacher development programme since it began in 2011. The language of teaching and learning in the school is English with 57% of the learners speaking isiXhosa as their home language. The school is a preparatory school for other Grahamstown schools and caters for Grades R to 5. The school was established in 1949 and is a former Model C school. The school also provides classes in music and art. The learners in the school represent a wide mix of racial groups and socio-economic backgrounds (Africans comprise 58.8%, Coloureds 24.1%, Indians 2.9% and Whites 14.2% of the school population). The school serves families that range from domestic workers to academics and charges fees just over R5000 per annum. The majority of learners arrive either via private or public transport. Extra-curricular activities are timetabled daily and are mandatory for both learners and educators alike. The school day extends to 13:30 to accommodate the extra-curricular time. In 2012, there were two grade 3 classes (Source: Chair Individual School Report, July 2012).

I discussed the idea of an after school club with the two Grade 3 class teachers and then approached the school principal to gain permission to run a club. I asked the class teachers to select up to a maximum of 12 learners from their combined classes. They selected learners who they thought would benefit from being in the club and who would not have problems with staying after school. Finding a time to run the club was challenging as the school had a full extra-mural programme. We eventually settled on a Tuesday from 2:30 to 3:30 pm. Parental consent letters were sent out and signed. The club started on the 21st

February 2012. The club was held in either of the grade 3 classrooms or in the school library. We had a total of 28 club sessions over the course of 2012. Unfortunately, the learners attended sport before they came to club, so the time was not ideal. They arrived saying they were tired and hot.

The learners in the club comprised 12 learners: six girls and six boys. The learners themselves are described in the Methodology chapter as they form one set of research participants for the study.

Luhlaza Primary

Luhlaza Primary has also participated in the SANC project's NICLE teacher development programme since 2011. The school was started approximately 18 years ago and was the first school in Grahamstown for black children that was English Medium. It serves grades 0 to 9 and some of its learners go onto Grahamstown's ex-Model C, ex-HoR and private schools in Grade 10. The socio-economic status of the learners covers a wide spectrum from children of the unemployed, to house cleaners, teachers, nurses, policemen, military and municipality workers. The majority of children come from Grahamstown while some are bussed in from surrounding farms. The home language of learners is predominantly isiXhosa whilst the language of learning and teaching is English. The school charges less than R1500 per annum for school fees. Africans comprise 100.0% of the school population. Very few learners have access to educational enrichment opportunities other than what they are exposed to via the school although the school does have an active choir and a library. Aside from parent meetings, there is no involvement from the community in the development of the school. The principal said that parent engagement is "zero" (Source: Chair Individual School Report, July 2012).

Mellony Graven and myself visited the principal of the school to discuss the idea of clubs. We then spoke with the Grade 3 teacher about setting up a club. She selected 10 learners for the club and parental permission was obtained for all learners. Taking into account issues with taxi transport, we settled on a Thursday from 1:15 to 2:00 in the school library. We had a total of 27 club sessions in 2012.

The club comprised 10 learners: five girls and five boys of mixed ability. The learners themselves are described in the Methodology chapter as they form a second set of research participants for the study.

Resources: Human and Physical

I was the mentor for both clubs. On two occasions Mellony Graven, as a fellow club mentor in the SANC project, joined the club sessions as a visiting mentor. When I was signed off for medical reasons for three weeks, she stepped in as fellow mentor and mentored the clubs for me.

I provided all teaching and learning resources needed for the activities I promoted in each session. For example, these included dice, playing cards, portable whiteboards (for mentor and learners), pencils, marker pens and activity specific resources such as number lines, game cards, 100 charts, worksheets and so on. Scrap paper was available at every session should the learners wish to use it. They also made use of the black/white board to show their workings if these were available.

In Elmtree Prep, different venues offered different resources for the club. The classrooms had mats near the blackboard, desks and chairs. The library, when we used it had a carpeted floor, some chairs but no desks or black /white board. In Luhlaza Primary, the library had a carpeted floor, some chairs and one large desk but no black/white board. We therefore did a lot of work on the floor and some children lay down to write and work.

3.5.2 ZONE OF PROMOTED ACTION: PROMOTED ACTIVITIES

The ZPA describes the activities that are promoted in the clubs. For this study, the ZPD was the critical design element for club sessions and as such had a direct influence on the kind of activities that were promoted in each club. Therefore the only activities planned in *advance* were the diagnostic assessment activities. The data and reflections from these activities drove the subsequent activities that were aimed at learning and development of mathematical proficiency for each learner within the ZPD. For example, in both clubs I worked on developing conceptual place value using a combination of mental activities and games and place value cards. Further descriptions of the activities used during the year are shown in Appendix M.

The overarching intention for any activity promoted in the case study clubs was the fostering of sense making and flexible thinking using an interwoven approach to the development, where possible, of the five strands of mathematical proficiency (Kilpatrick et al., 2001). Specifically, in terms of procedural fluency, my focus was on developing three elements in order to take the attention away from using traditional algorithms: efficiency, accuracy and flexibility.

3.6 CHAPTER THREE: CLOSING REMARKS

In this chapter, I have explained the broader context in which the clubs operate and more specifically, I have shown how the lessons learnt from the pilot club in 2011 have shaped the formation and structure of the research clubs used for this study. I have used the Zone Theory framework to describe the two research clubs using the ZPD, ZFM and ZPA constructs. I also shared insights concerning the ZPD construct in the Zone Theory design. I discuss the ZPD further as an *analytic tool* in the Methodology chapter.

---- END OF CHAPTER THREE ----

CHAPTER 4 METHODOLOGY

4.1 RESEARCH QUESTIONS AND CHAPTER OUTLINE

My primary research aim was to investigate how learners' mathematical proficiency levels evolve in relation to their participation in informal after school maths clubs. This was broken down into two specific research questions:

1. How do learners' mathematical proficiency levels evolve (if at all) over the period of participation in the maths club?
2. What is the nature of the mediation that enables or constrains the emergence of a ZPD in the clubs?

This chapter details how the research study was designed to undertake this investigation and is structured as follows:

Section 4.2
In this section I situate the study in a broader research paradigm. I examine and review alignment between the theoretical, conceptual, methodological and analytical frameworks of my study.

Section 4.3
In this section I specify the type of design used for the research including the research timescale and the learners who participated in the two case study clubs.

Section 4.4
In this section I deal with the data collection methods and instruments and include a discussion of the dual nature of the instruments.

Section 4.5
In this section I examine the approaches I used to analyse the data generated.

Section 4.6
In this section I review the methodological tensions and dilemmas that arose during the study.

Section 4.7
In this section I document the ethical considerations and discuss authenticity issues for my study.

Section 4.8
In this section I make concluding remarks about the methodology.

4.2 RESEARCH PARADIGM

Vygotsky himself was at different times a researcher and a teacher and he used genetic analysis to develop his theoretical framework and guide his research. He stressed the need to concentrate not only on the *product* of development but on the *process* of change (Vygotsky, 1978). The theoretical background I have discussed for this enquiry points to an *interpretive* research paradigm and coheres with the Vygotskian perspective adopted for this study. From this perspective, research should be observed from inside and through the direct experiences of the people involved. Cohen, Manion, and Morrision (2000). state that the interpretive paradigm recognises that: "people actively construct their social world", events and behaviour evolve over time and are richly affected by context (they are 'situated activities'), "events and individuals are unique and largely non-generalisable", there are multiple interpretations of, and perspectives on, single events and situations, reality is "multi-layered and complex" and many events are not reducible to simplistic interpretation, hence 'thick descriptions' are essential (p.22). For this study, the elements of interpretive research that particular resonated were that events and situations are unique and that they evolve over time. Those events are interpreted by people in different ways and subsequently act on the events that occur in different ways.

Interpretive research aims to "understand the subjective world of human experience" (Cohen, Manion, & Morrision, 2000, p.22). It focuses on understanding the actions and meanings that shape participants behaviour and the conclusions reached are relative to the particular context in which the research occurs.

METHODOLOGICAL ALIGNMENT WITH FRAMEWORKS IN THE STUDY

One important aspect of a research study is the coherence between the frameworks used. Below I present a table which illustrates how the frameworks in this study align and use it as a basis for the discussion that follows. Table 4 below is divided into four major sections, represented by four columns. These sections represent the *theoretical, conceptual, methodological and analytical* frameworks used. The rows represent the relationship between the different aspects *across* the frameworks. Further detail on each aspect in the table is discussed in the chapter noted in the table and in the descriptions that follow.

Table 4: Alignment between frameworks in this study

ALIGNMENT BETWEEN FRAMEWORKS			
THEORETICAL Chapter Two	**CONCEPTUAL** Chapter Two	**METHODOLOGICAL** Chapter Four	**ANALYTICAL** Chapter Four
Broad socio-cultural perspective		Interpretative paradigm Case study design Qualitative data with some quantifiable data	
Vygotsky	Linking mathematical progression and fluency to Vygotsky	From theoretical standpoint of Vygotsky: • Researcher's role • Research participants • Research context (Empirical field) • Means of data collection (see below§)	**Overall approaches used:** Change over time and basic statistical analysis (Q1) Constant comparison and grounded approach for attention catching mechanisms (ACMs) (Q2)
Learning and development	Progression of mathematical proficiency (Q1) ZPD (Q2)		
Internalisation	Progression of mathematical proficiency (Q1) ZPD (Q2)		
Everyday and scientific concepts	Wright et al (2006) Mathematical progression LFIN (Q1) Fluency: Mathematical proficiency (Kilpatrick et al, 2001) (Q1)	§MP interviews (Q1) §Fluency assessments (Q1)	LFIN framework (Q1) 3 Strands of mathematical proficiency (CU, PF, AR) (Q1)
ZPD **	ZPD (Q2) Meira & Lerman (2001, 2009) Attention Catching	§Task-based-interviews (Q2)	ZPD emergence & sustainment via ACMs (Q2)
Mediation	Anghileri's (2006) Scaffolding (Q2)	§Task-based-interviews (Q2)	Nature of mediation and relationship between this and ACMs (Q2)

Starting with the *theoretical framework* (column one), I list the major theoretical ideas from a Vygotskian perspective used in my study, which are discussed in Chapter Two, namely: learning and development, everyday and scientific concepts, internalisation, the ZPD and mediation. The second column shows the *conceptual notions* that I use in the study, mostly in connection with the two research questions, that is: mathematical proficiency, the LFIN, fluency, the ZPD, scaffolding and attention catching. In Chapter Two, I explained each of these concepts and illustrated how they cohere with both the theoretical framework and how they address the research questions. In the table, each concept is placed next to the theoretical notion where the connections and coherence are evident and as such the relationship is illuminated.

The *methodological framework* is portrayed in column three, exemplifying how each aspect of the research design links with both the theoretical and conceptual framework. So, from Vygotsky's theoretical standpoint, I documented the role of the researcher, the research participants, the research context and methods of data collection for my study. Each data collection instrument for each research question is linked directly with both theoretical and conceptual ideas. For example, *mathematical proficiency interviews* and *fluency assessments* were used to gather data for question one. The construct of these interviews and tests are linked directly with the conceptual and theoretical frames of mathematical progression, fluency and everyday and scientific concepts. Likewise, task-based interviews are the data collection instrument for investigating the nature of mediation for question two. These interviews were focussed on collecting data that will provide evidence for the emergence of ZPDs, attention catching mechanisms and mediation in the form of scaffolding. I discuss these interviews in detail later in this chapter.

The final column represents the aspect that is most frequently misaligned or forgotten according to Smagorinsky (2008), that of the *analysis framework*. This column shows that overall analysis approaches used (basic statistical analysis, constant comparison and grounded approach) and then the specific frameworks or filters for each research question. These analysis frameworks are linked directly with the conceptual framework, which in turn is connected to the theoretical framework. To elucidate, for question one, the analysis framework is the LFIN along with the three strands of mathematical proficiency. In other words, the data is analysed and reported using the descriptive language (or the codes) of the two frameworks. Similarly, the ZPD, attention catching mechanisms, mediation and scaffolding are used as the language (or the codes) for analysis and reporting of question two (see later in this chapter for discussion).

4.3 RESEARCH DESIGN

> *A research design is the logic that links the data to be collected (and the conclusions to be drawn) to the initial questions of study. Every empirical study has an implicit, if not explicit, research design. Articulating "theory" about what is being studied and what is to be learned helps to operationalize case study designs and make them more explicit (Yin, 2009, p. 24).*

This section on research design looks at the broad type of research design, the timescale of the study and the participants involved in the study. In sections 4.4 and 4.5 I turn my attention to methods of data collection and analysis strategies.

4.3.1 TYPE OF STUDY (RESEARCH STRATEGY)

My study was a *longitudinal, largely qualitative multi-site case study* using two after school maths clubs with data collection occurring at different points over a one-year period from February to November 2012. These clubs were run at two of the SANC project's schools as described in Chapter Three. I briefly discuss the reasons I chose to use the case study design. As an empirical study, the case study approach is an approach to qualitative research that "investigates a contemporary phenomenon in depth and within its real-life context" (Yin, 2009, p. 18). Denscombe (2010) characterises case study research as emphasising:

- depth of study rather than breadth of study
- the particular rather than the general
- relationships/processes rather than outcomes and end-products
- holistic view rather than isolated factors
- natural settings rather than artificial situations
- multiple sources rather than one research method (p. 54)

A case study approach therefore allowed me to investigate the phenomenon of the maths clubs in depth and portray, analyse and interpret the complexity and uniqueness of real learners and their situation within the real-life context of the clubs (Cohen et al., 2000). Yin (2009) states that the same study may contain more than a single case. As I am using two clubs, my design uses what he calls the *multiple-case design variant*. Yin (2009) considers single and multiple-case designs to be variants within the same methodological framework and states that the evidence from *multiple cases* is often considered more compelling, and the overall study is therefore regarded as being more robust.

One of the strengths of the case study approach is that it allows the researcher to use a variety of sources and types of data and a variety of research methods as part of the investigation. “It not only allows this, it actually invites and encourages the researcher to do so” (Denscombe, 2010, p.54). This in turn can facilitate the validation of data through triangulation.

Denscombe (2010) points out that the researcher using a case study approach is likely to confront doubt about the findings. This arises from doubts about how far it is reasonable to generalise from the findings of the case. He advises that it is good practice for any researcher using a case study approach to “pre-empt possible criticism by addressing the issue head-on” (p. 60). He suggests that one can prepare an “explicit defence” against the allegation that you cannot generalise from case study findings, using these three arguments.

- Although each case is in some respects unique, it is also a single example of a broader class of things ...
- The extent to which findings from the case study can be generalised to other examples in the class depends on how far the case study example is similar to others of its type ...
- Reports based on the case study must include sufficient detail about how the case compares with others in the class for the reader to make an informed judgement about how far the findings have relevance to other instances …
  (Denscombe, 2010, pp. 60–61)

For this study I have addressed these as follows. As the researcher I have drawn wider inferences from the study of the case by identifying significant features on which comparison with others in the class can be made and to show how the case compares with others in the class in terms of these significant features. Denscombe (2010) suggests for example that one can use social location features to make comparisons My case study is based on two after school maths clubs. Although maths clubs are still a new idea in the SANC project and South African education, they are still examples of the broader class of OST programmes reviewed in Chapter Two. Many of the social location features and institutional features Denscombe (2010) suggests are detailed in Chapter Three in the description of the two schools used in the empirical field, allowing others to make comparisons between the case from this study and others that are similar.

4.3.2 RATIONALE AND SELECTION OF CASES

Bishop (2010) indicates that the terms multi-site and multi-case are used interchangeably and defines a multi-site study as a “contemporary phenomenon that is common to two or more real-world” (p. 587) settings and can reveal “within-site patterns and cross-site syntheses” (p. 589). The research design in a multi-site case study is the same across all sites and all sites are studied using the same key research questions, with the same data collection, analysis, and reporting approaches. This is valid for the two clubs in this study. Yin (2009) states that analytic conclusions arising from two cases “will be more powerful than those coming from a single case” (p. 61). Therefore, the multi-site study would also increase to some extent the broader applicability of the findings and enable the use of the comparison to support my conclusions, thus strengthening the case for external validity.

These definitions resonated with my situation and I thus chose to design a *multi-site* study of clubs at two schools. One school was a township school and the other was an ex-model C school. Club participants were drawn from the Grade 3 learners in these schools as described in Chapter Three. Although this choice was based primarily on the schools being located in Grahamstown and the LOLT being English[12], I wished to maximise diversity as much as possible and for the schools to be “as like the population of interest as possible” (Firestone, 1993 p.20).

According to Cohen et al. (2000), my case is a ‘*non-probability sample*’ as I targeted a particular group, in the full knowledge that it does not represent the wider population; it simply represents itself. Furthermore my case is of the ‘*convenience*’ sampling type (Denscombe, 2010) which is also known as accidental or opportunity sampling which involves choosing the nearest individuals to serve as respondents (2000, p. 102).

[12] It was important for the LOLT to be English as I am unable to speak isiXhosa and I am not fluent in Afrikaans

The learners in the two case study clubs

Chapter Three detailed the two schools at which the clubs took place. The Elmtree Prep club originally comprised of 12 learners: six girls and six boys. These learners were indicative of the broader school population in terms of ethnicity. Early on in the study, a number of learners left the club due to issues with transport, reducing the number of club learners to seven. The Luhlaza Primary club comprised of ten learners: five boys and five girls who attended the club for the entire year. Table 5 below details the characteristics of the learners in each club.

Table 5: Characteristics of learners in the two case study clubs

Learner Pseudonym	Gender	Age at start of study	Home language	Ethnicity	Participated in both MP interviews?	Participant in task-based interview?
Club (Site) One: Elmtree Prep						
Anathi	Female	9	isiXhosa	African	Yes	Yes
Cebisa	Female	8	isiXhosa	African	Yes	No
Kholeka	Female	8	isiXhosa	African	Yes	No
Nate	Male	8	English	White	Yes	Yes
Thembela	Female	9	isiXhosa	African	Yes	Yes
Zac	Male	8	English	Asian	Yes	Yes
Zintle	Female	9	isiXhosa	African	Yes	No
Club (Site) Two: Luhlaza Primary						
Sipho N	Male	9	isiXhosa	African	Absent [13]	No
Sipho C	Female	9	isiXhosa	African	Absent	No
Emi	Male	8	isiXhosa	African	Absent	Yes
Oma	Male	8	isiXhosa	African	Absent	Yes
Siphiwe	Female	9	isiXhosa	African	Absent	No
Apolo	Male	8	isiXhosa	African	Absent	No
Aphiwe	Female	9	isiXhosa	African	Yes	No
Akhona	Female	9	isiXhosa	African	Yes	Yes
Chebe	Male	9	isiXhosa	African	Yes	No
Kuhle	Female	9	isiXhosa	African	Yes	Yes

[13] The second MP interview took place in November 2012. On the day that I arranged to visit the school, only four of the 10 learners were at school. Subsequently I have realised that for many schools attending school is 'optional' in the last few weeks of the school year after exams are written.

4.3.3 RESEARCH TIMESCALE

Table 6 below shows the data collection schedule for the duration of the research study. The Maths Clubs ran one afternoon a week at each school during term time giving a total of 28 club sessions for Elmtree Prep and 27 club sessions for Luhlaza Primary. As two research clubs were selected as cases, simultaneous data collection took place in both of these which allowed for comparisons between the two clubs on an on-going basis.

Table 6: Data collection schedule for 2012

	Data Collection methods		
	Research Question 1		Research Question 2
Timescale	One-to-one MP Interviews	Fluency Assessments	Task-based interviews
March 2012		Elmtree Prep Luhlaza Primary	
April 2012	Elmtree Prep Luhlaza Primary		
May 2012			
June 2012			
July 2012		Elmtree Prep	2 paired interviews for Luhlaza Primary
August 2012		Luhlaza Primary	
September 2012			
October 2012			2 paired interviews for Elmtree Prep
November 2012	Elmtree Prep Luhlaza Primary		

The next part of this chapter is divided into two sections: *section 4.4* details the methods and instruments used for collection of data and *section 4.5* discusses the analytic frameworks and filters used in the analysis of the data for the study.

4.4 DATA COLLECTION METHODS AND INSTRUMENTS

Introduction

I return briefly to Smagorinsky (1995) as the preface to this section. In connection with data collection instruments he argued that within the Vygotskian perspective of development, the instruments of data elicitation are *mediational* rather than neutral. He elucidated thus:

> *to assume that the study of learning can take place outside the bubble of the social environment of learning is to misconceptualize the role of mediation in human development and to underestimate the effects of the introduction of any research tools into the learning environment (p.204).*

Additionally, he argued that if the socially constructed data is to count as evidence for making claims in research, then there is a relationship between the assumptions about the optimal end point of development and the assumptions about the data that serve as evidence of *progress* towards that point. Therefore any assessment instrument "embodies the researcher's sense of an appropriate developmental path for people to follow, and produces data that identifies people's progress ... according to the direction of the path" (p.200). In other words, the research process produces culturally shaped evidence of development towards a specific end point.

This was important for this study. As the researcher, I chose to use the LFIN framework to represent the developmental path of mathematical proficiency for learners in my study. In addition, as will become clear as I discuss data collection methods for question one, I used an instrument which embodies the concepts of the LFIN to collect data on the club learners' progress. Similarly, for question two, I used a data collection method (task-based interviews) that highlighted the importance of talk and dialogue between participants. Thus the interview instrument was introduced into the learning environment and was mediational in nature.

Dual nature of the data collection instruments

As previously discussed, my study was interwoven with the notions of the acquisition and participation metaphors (Sfard, 1998). Moreover, earlier I highlighted that Vygotsky stressed the need to not concentrate only on the *product* of development but on the *process* of change (1978). As such, both of these ideas are evident in how I collected data to answer the two research questions. Another key aspect of Vygotsky's research method was that he saw results as "qualitative as well as quantitative in nature" (Cole & Scribner, 1978, p. 14). This was the case with this study. Yin (2012) supports the idea that case study designs can include both qualitative and quantitative data.

Question one looked at the measurement of possible learning for each club learner. The data collection instruments used in this study allowed me to measure this possible learning using diagnostic and formative methods. The data yielded individual data for each learner and was a mixture of both qualitative and quantitative data. For question two (where the participationist view was foregrounded), I collected video data that helped me to observe the process of how this learning was facilitated. This data was qualitative as I focussed on the activities and interactional aspects of learning in the context of the two clubs. This dual nature of the data collection instruments is shown diagrammatically in Figure 9 below.

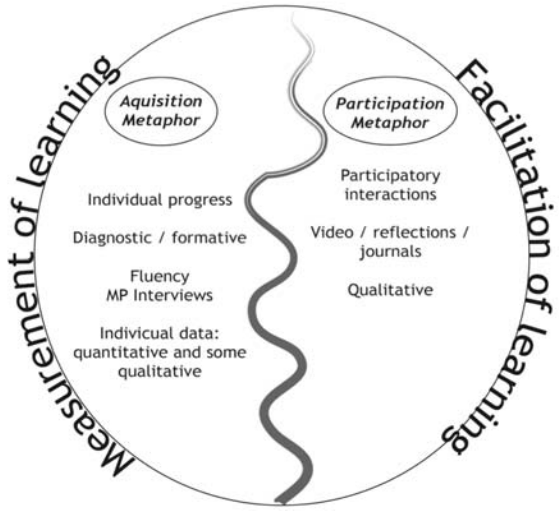


Figure 9: Dual nature of data collection instruments for this study

I base this subsequent discussion of data collection methods around the summary shown in Table 7 below. For *each* data collection method I detail the following:

A. How the instrument evolved or was selected for the study
B. The structure of the instrument
C. How the instrument was administered and the data collected
D. The source and format of data derived from the instrument

In addition to the main data collection instruments described below, as a participant-observer, I kept an on-going, detailed research journal, collected learner work samples and took photographs.

Table 7: Methods of data collection summary

	Question 1: Evolving Mathematical Proficiency (Acquisition metaphor)		**Question 2: Nature of Mediation (Participation metaphor)**
Collection Method	Mathematical Proficiency (MP) Interview: A one-to-one oral interview with each club learner	Fluency assessments	Task-based interviews with pairs of learners
Frequency of data collection	April 2012 November 2012	March 2012 July / August 2012	Luhlaza Primary - August 2012 Elmtree Prep - October 2012
Source of data	Interview script for each learner on which interviewers noted answers and made notes	Assessment scripts for each learner on which they wrote their answers	Video (of interactions between participants)
Nature of collected data	Qualitative and quantitative	Largely quantitative	Largely qualitative
Format of data	Learner LFIN profiles in text and numbers (methods of answering, scores and levels)	Performance scores	Strategically selected segments (episodes) from video corpus

4.4.1 ADDRESSING QUESTION 1: MATHEMATICAL PROFICIENCY INTERVIEWS

In the Empirical Field chapter I explained that it was necessary to use a different data collection instrument for tracking progressing mathematical proficiency following the pilot club. I refer to this as the Mathematical Proficiency interview or MP interview in short.

For this instrument I drew on the work of Askew and his team in the *Effective Teachers Of Numeracy* study conducted in England in the nineties (Askew et al., 1997). The SANC project was given permission to use the instrument and hence I was able to select and adapt various items used in their study. The assessment items that I have included in the MP Interview instrument were drawn from the Year 2 and 3 scripts used by Askew et al. (1997). However the work of Wright, Martland and Stafford (2006) on Mathematics Recovery also provided excellent examples of assessment items that enabled me to gauge learner progress through various stages of numeracy development and aligns with their LFIN. My instrument thus combines elements from these two research projects.

The MP interview instrument consisted of 24 tasks in total. Individual questions were grouped together to form a full picture for a particular aspect of early numeracy, for example conceptual place value.

Together Tables 8 and 9 give details of how the interview instrument was structured. Table 8 details each individual task, its order in the interview, which aspect of the LFIN is addressed and the origin of the question (either Wright et al., 2006 or Askew et al., 1997).

Table 9 illustrates the spread of tasks across the LFIN aspects (which are discussed in detail in section 4.5). The full interview script is given in Appendix B.

Table 8: MP interview: Summary of instrument structure

Task no.	Task Number & Description	No of subparts in task	Aspect of LFIN addressed [14]	Origin of question
Interview part 1				
1	Numeral Identification	10	Aspect B	Wright et al.
2	Number line representation	2	Aspect B	Askew et al.
3	Forward number word sequences	3	Aspect B	Wright et al.
4	Backward number word sequences	3	Aspect B	Wright et al.
5	Number word before	6	Aspect B	Wright et al.
6	Number word after	6	Aspect B	Wright et al.
7	Sequencing numerals	2	Aspect B	Wright et al.
8	Perceptual counting	2	Aspect B	Wright et al.
9	Counting in incrementing 10s	5	Aspect C	Wright et al.
10	Addition/subtraction with 10s	4	Aspect C	Askew et al.
11	Addition/subtraction with 100s	4	Aspect C	Askew et al.
Interview part 2				
12	Horizontal +/- sentences	4	Aspect D	Wright et al.
13	Word problems	3	Aspect D	Askew et al.
14	Number stories	1	Aspect D	Askew et al.
15	Non counting by 1s	6	Aspect D	Wright et al.
16	Number combinations	6	Aspect A	Wright et al.
Interview part 3				
17	Visible items in an array (Subitising)	3	Aspect E	Wright et al.
18	Visible items in an array (Subitising)	2	Aspect E	Askew et al.
19	Visible items in an array (Subitising)	2	Aspect E	Askew et al.
20	Equal grouping of visible items	3	Aspect E	Wright et al.
21	Equal grouping of visible items	2	Aspect E	Wright et al.
22	Equal grouping of visible items	3	Aspect E	Wright et al.
23	Times tables	4	Aspect E	Askew et al.
24	½ and ¼ of a collection	2	Aspect E	Askew et al.
	Number of Wright et al. questions	63 in 15 tasks		
	Number of Askew et al. questions	25 in 9 tasks		
	Total number of questions	**88 in 24 tasks**		

Table 9: MP interview: Summary of tasks and questions in each LFIN aspect

LFIN Aspect ➔	Structuring nos 1 to 20 Aspect A	No words & numerals Aspect B	Conceptual place value Aspect C	Early arithmetic strategies Aspect D	Early multiplication & division Aspect E
Task Numbers	**16**	**1 to 8**	**9, 10 and 11**	**12 to 15**	**17 to 24**
No. of **tasks** for each aspect (24 in total)	1	8	3	4	8
No. of **questions** for each aspect (88 in total)	6	34	13	14	21

[14] **See Table 9 for aspect names.**

How the instrument was administered and data collected

A script was printed for each learner for each interview. The interviewer used this to ask the interview questions and to make notes about learners' answers and the methods used to answer questions. Interviewers also noted speed of answering and anything the learner may have said whilst working on a task or question. Interviews lasted between 45 to 60 minutes and took place during school hours. Questions were asked orally in English and learners were provided with paper and pencils for workings if they needed it. Resources (such as counters) were provided as specified by each task.

For Elmtree Prep, the first interviews were administered in April 2012. I gained permission from the principal and the Grade 3 teachers to start early in the morning. Myself and other SANC project members (who had been previously trained to administer the instrument) took four children at a time out of class and each undertook an interview with the child. Thus the interviews were completed over the course of three mornings and caused minimum disruption to the learners and teachers. We approached the interviews for Luhlaza Primary in the same way and completed the interviews in two mornings for ten learners.

The second MP interview was administered in November 2012. Myself and one other team member undertook the interviews with the seven learners at Elmtree Prep and we completed them in one morning as each interview took about 30 minutes (less than they did in April). The end of the school year for Luhlaza Primary was a little disrupted, as towards the end of the school year after exams, many learners did not come to school. Thus I only managed to interview four of the ten club learners in November. Indeed, South African researchers (see for example Vithal, 1998) note that much research in South Africa can be unexpectedly affected by 'disruptions'.

This instrument yielded rich qualitative data mostly in the form of a profile for each leaner against the LFIN framework, the methods used to answer the questions and the time it took for the learner to do so. This qualitative data enabled me to tell detailed stories about learners in the clubs[15] as will be evident in subsequent chapters. Analysis of the methods used by learners to answer questions enabled me to profile where each learner was in terms of the aspects and stages of the LFIN and allowed me to see a clear picture of how each

[15] See for example Graven and Stott (2012b)

individual learner was progressing over time. This notion was central to how I planned club activities and mediatory interventions after the administration of the first MP interview. I also used the data from the interviews to develop a scoring system, which I describe below.

Extending the LFIN to obtain quantifiable data

In his 2003 article Bob Wright specifically stated that that one-to-one MR assessment "does not result in a score" (p.8) and the interview data is always used to profile the individual child's stage of early number learning in the LFIN using stages and levels. This was re-affirmed during an informal conversation with him during one of his workshops at the Early Childhood Research and Development Week held in Grahamstown in September 2012.

However, I argue that such scoring can be useful in relation to my study. In the clubs I tried to balance the needs and progress of the whole group with those of the individual learners. It is this quantifiable data that helped me to zoom out from individual detail and see the broad picture for a club as a whole and where overall areas of strengths and weakness lay. During the same workshop conversation with Bob Wright mentioned above, he thought that it might be useful to explore this notion further for looking at progress of a group of club learners. After conducting the first series of interviews and entering the scores I was able to see where the club learners had achieved high scores and low scores. Even at this broad level I was able to use this information to plan activities for the whole club that addressed areas of weakness.

Working as I do in many clubs (subsequent to my research clubs), it is useful to be able to compare different clubs to each other. By working with percentages, I was able to usefully aggregate these scores in order to make comparisons across more than one club using tables and graphs. These types of comparisons across the whole club or sets of clubs are not easily noted from the aspect stages or levels detailed within the LFIN itself, as each set of stages or levels is profoundly different and one would not be comparing like with like. An example may help to illustrate. The '*early arithmetic strategies'* aspect has 6 stages numbered from 0 to 5 with a particular set of descriptive characteristics whilst the '*conceptual place value'* aspect has 3 levels numbered from 1 to 3 with a completely different set of descriptive characteristics (see Table 10). Therefore it is not possible to aggregate using the stage or level numbers.

Table 10: Stages for two LFIN aspects

Aspect D: Early arithmetic strategies (Stages)		Aspect C: Conceptual Place Value (Levels)	
0	Emergent counting	1	Initial concept of 10
1	Perceptual counting	2	Intermediate concept of 10
2	Figurative counting	3	Facile concept of 10
3	Initial number sequence		
4	Intermediate number sequence		
5	Facile number sequence		

In line with my need to see both the broad and detailed picture, I generated quantifiable data which I call 'Mathematical Proficiency (MP) Interview Scores'. I generated and worked with *three* types of scores: first an *overall score* (or mark) for each individual interview expressed as a percentage. Secondly, I generated a *percentage score for each aspect of the LFIN*. Finally, I used these generated scores to *aggregate* across the club as a whole and across more than one club by working out averages, counts and so on. These different types of data gave a rich picture of where each club learner was in their Early Number learning.

Generating this quantifiable data was achieved by using a Boolean system of scoring, thus entering a '1' for an accurate answer and a '0' for an inaccurate one into a standard spreadsheet. Totals were created for each learner and additionally, for each different LFIN aspect.

I illustrate with one example. Table 9 showed that interview tasks 12, 13, 14 and 15 make up the *early arithmetic strategies* aspect (aspect D). Task 12 had four questions, Task 15 had six questions and Tasks 13 and 14 another four questions, making a total 14 questions for this aspect. If each correct answer was allocated a '1', then the highest possible score for this aspect was 14. In order to arrive at a percentage score for the entire interview and for each aspect, the question scores for each aspect were added up and divided by the total possible score for the interview and each aspect respectively.

One could argue that the relatively small amount of items in some of the aspects (namely B, C and D) is a limitation of this approach. A correct or incorrect answer to one question can translate into a large percentage change. However, while acknowledging this problem, due to the careful structuring of the underlying interview items, these changes are important and reflect mathematical progress. For example, in task one, the numbers in the task are structured in such a way that they show progression from naming single digit numbers to four digit numbers and simple fractions. Results from the interviews across the research clubs showed that grade 3 club learners often struggled with saying the correct number names for 208, 1025, ½ and ¼. Being able to correctly say these at a later stage shows progress.

A drawback of using percentage scores and aggregations is that they do not show the more in-depth story of how learners arrived at their answer, or how efficient or sophisticated their chosen method of working it out was, which is a key aspect of a qualitative case study. As discussed, this is where the intended use of the LFIN is relevant for my research.

4.4.2 ADDRESSING QUESTION 1: FLUENCY ASSESSMENTS

As discussed in Chapter Three, one activity that I devised for the clubs in the pilot was a series of written timed activities aimed at supporting learners to improve their fluency, specifically in speed and accuracy of recall of the basic facts such as halving and doubling. Using ideas derived from Askew's (2009) article, these activities were initially intended to be part of the range of mental activities I promoted in the clubs. The pilot revealed that these were useful as a research data collection instrument to supplement the MP interview data as they took only ten minutes and were easy to administer.

While these assessments in this form were useful, an ethical tension arose for me as timed activities are by design time pressured and thus can be stress inducing for learners. Indeed, a review of literature reveals a sizable body of work that puts forward an argument against timed activities in mathematics. I understand these arguments and the anxiety and negative attitudes they can cause in learners and have heard learner stories of being 'turned off' maths because of frequent timed tests.

Boaler (2012) explained that many "erroneously equate fluency with timed testing". Gilliland (2001) writes that learners are unlikely to be motivated by timed tests and that these high-stress situations cause competitiveness, decrease in learner confidence and engender a dislike for mathematics. In spite of this, timed tests are frequently used as a tool to identify good or high performing mathematics students, to make decisions about the extent of a learner's mathematical knowledge and for determining whether a learner passes a particular grade or not.

Boaler (2012) pointed out that the stress caused by maths anxiety impedes the functioning of a child's working memory and reduces mathematical achievement. Added anxiety becomes part of a negative maths anxiety dynamic, which can contribute to failure in mathematics and to the future avoidance of mathematics as a subject choice. Additionally, Burns (2007) put forward the argument that timed tests do not measure learners *understanding*. She pointed out that the tests can emphasise memorisation and do not guarantee that learners understand or that they will be able to use the facts in problem-solving situations. She concluded “it conveys to children that memorising is the way to mathematical power, rather than learning to think and reason to figure out answers” (p.192).

However, many mathematics educators believe that fluency can be developed and improved with practice without the need for rote learning or drilling (Anthony & Walshaw, 2009; Kilpatrick et al., 2001). One dilemma facing mathematics educators is how to develop this fluency without creating the stressful situations that are associated with timed activities. Askew submitted that thoughtful use of practice can help develop fluency and suggests that the development should encompass “practice and problem-solving, understanding and (appropriate) rapid recall” (Askew 2009 p. 27).

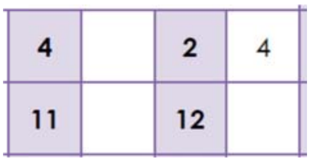
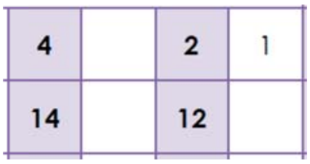
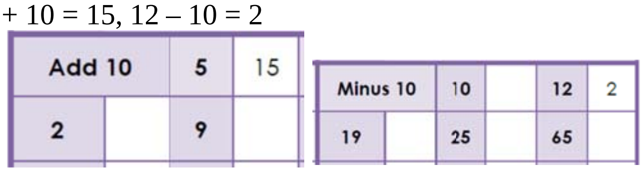
Askew (2002) advocated that learners can be encouraged to engage in different types of practice to develop fluency: *guided practice* when learners still need the help of a more experienced other to keep them on track; *over-practice* where learners practice the same thing every day and finally *deliberate practice* where what learners practice is made harder by setting a time limit or by working with bigger numbers. The core of deliberate practice seems to be continually stretching the learner to just beyond his or her current abilities (Askew, 2002; Pegg, 2010).

Askew (2009) suggested one way to engage in deliberate practice for fluency development is by using time trial activities. He shared his ideas for using these controversial activities with a different focus and emphasis, arguing that they can be motivating for the learner. Given the dual concern for research and development in working with the learners in my clubs, a tension arose between the stresses learners experience in relation to the timed aspect of the assessments and the usefulness of the means of gathering data on a regular basis. Later in this chapter, I exemplify how I dealt with this ethical tension by utilising these assessments as a reflective tool, which enabled learner buy-in of the process and increased motivation.

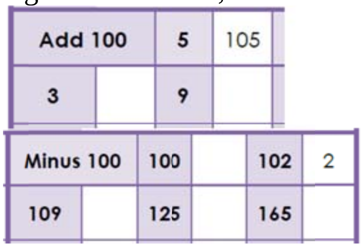
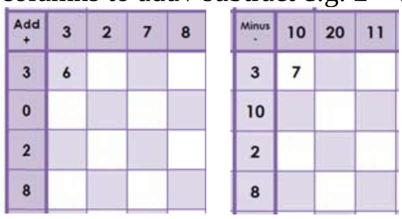
Structure of the instrument and how it was administered

Six different individual assessments combine to make up these timed fluency assessments. Each individual assessment was completed in a specified amount of time. Table 11 below describes and gives a sample of each activity, details the time allocation and total marks for each activity. These examples are cropped to save space but full examples of the activities are included in Appendix C.

Table 11: Description of fluency assessments instrument

Assessment type	Description & Sample	Time allocation	Activity out of …[16]
Add and subtract to 10	Number range up to 10 Use the numbers in the shaded header rows and shaded columns to add / subtract e.g. 2 + 3 = 5 and 10 – 2 = 8 	1 minute for add 1 minute for subtract	48
Doubling	Double the shaded number e.g. double 4 is 8, double 2 is 4 	1 minute	17
Halving	Halve the shaded number e.g. half 4 is 2, half 2 is 1 	1 minute	17
Add / subtract 10	Add 10 to / subtract 10 from the shaded number. e.g. 5 + 10 = 15, 12 – 10 = 2 	1 minute	20

[16] **Note**: Each answer is worth 1 mark. This column therefore also represents the number of required responses. In addition, the example sum in each test is not scored.

Assessment type	Description & Sample	Time allocation	Activity out of …[16]
Add / subtract 100	Add 100 to / subtract 100 from the shaded number. e.g. 5 + 100 = 105, 102 – 100 = 2 	1 minute	20
Add and subtract to 20	Number range up to 20 Use the numbers in the shaded header rows and columns to add / subtract e.g. 2 + 3 = 5 and 10 – 2 = 8 	2 minutes for add 2 minutes for subtract	48

The instrument was administered individually to each learner in both research clubs during club time. As each activity only took a few minutes to do, I was able to do at least 3 activities at the beginning of a club session. In both clubs, these were administered in March and July / August of 2012.

Each learner script for each fluency assessment was named and dated. The scripts were used to work out each of the scores detailed in section 4.5 below. These scores were then entered into a spreadsheet for analysis purposes and were not shared with the learners or used to make public comparisons.

4.4.3 ADDRESSING QUESTION 2: TASK-BASED INTERVIEWS

I had always planned to use video of the club sessions as the data collection method for this question. In the first half of the year I attempted to collect video data in every club session. As I describe in the section on Methodological Dilemmas below, this proved to be challenging. It transpired that I was collecting a lot of data but it was not particularly useable because of general noise levels that made transcription of learner talk a problem.

I talked this problem through with Mellony Graven (my supervisor) and after some preliminary reading on task-based interviews, I decided that I would use task-based interviews as a data gathering tool to collect focussed and rich video data for this question. Task-based interviews are generally designed so that the interviewees interact with the interviewer and with each other but also with a task that is carefully designed for the purposes of the interview (Maher & Sigley, 2013). Maher and Sigley (2013) highlight that a carefully constructed task is a key component of the task-based interview. They further suggested that as the interviewees are engaged in mathematical activity, the researcher is able to observe their actions and record them with video. In my case, one mentor facilitated the interview and another recorded the video. These recordings, along with transcripts of the recordings, interviewees work and post interview reflections provided the data for analysis.

I had some concerns that these task-based interviews were contrived as learning situations, but Prof Steve Lerman[17] pointed out that all learning situations in formal classrooms are ultimately contrived. When conducting the interviews, I emphasised to the learners that these interviews were similar to being in the club environment and that during the interview, we would participate and interact the same way as we did during normal club sessions (I often worked with pairs of learners and moved from one pair to another). The only difference was that it was quieter and there were only two learners at a time, so we were able to record their discussions. I also carried out the interviews in the same venues used for the clubs, in order to add to the learners’ comfort levels. The following extract from a transcript with the two girls at the Elmtree Prep club illustrates how I introduced the interview:

[17] I worked with Prof Lerman at the SAARMSTE research school in June 2012 on my video data and we had a discussion about how I was to resolve the issues I was having with collecting video data.

> *Can I just explain what we're doing? Alright. You know I try and video the club sometimes and I find it really hard because I have to run around with all the groups and they're all doing different things and also I can't hear properly what's going on.*
>
> *So what we decided to do is we've done a little mini club with the boys and we're going to do a little mini club with you two. Okay? So that we can hear and we can see and get some proper video because the stuff that I do in the club normally doesn't work very well.*
>
> *All right, so all the club things that we know, about talking to each other, arguing with each other, giving your opinion, trying, working together. All those things that we do in the club. I want you to pretend this is just a club, but it's just the two of you. (Video recording, 19th October 2012)*

For the purpose of my study, I use the phrase 'task-based interviews' to mean those in which there were two interviewees (club learners) and one interviewer (club mentor). The main focus of the interview was to facilitate the learners in undertaking various carefully selected tasks with the aim of eliciting learner talk and thus providing data which focused on the nature of mediation in the clubs and how this may enable or constrain the emergence and sustainment of ZPDs in club learners. More specifically I wanted to examine a number of key aspects: how participants caught each other's attention and the overall nature of mediation used by the mentors.

Structure of the instrument and how they were administered

I selected tasks for the interviews that would be suitable for a whole club session in other circumstances. The same tasks were used for all interviews across both clubs and are explained below.

TASK 1 – MINI NUMBER BOARD PUZZLE

15	35	20	• Can you predict which row has the highest total? • Add together the numbers in first row. What strategy did you use? • Which three numbers total 38? • Are there other numbers that total 38? You can add together as many numbers as you like to total 38.
6	14	8	
12	40	10	

TASK 2 - MONEY

TASK 2a – TUCK SHOP PROBLEM

TUCK SHOP SNACKS Drink R2 Burger R5 Chips R3	Debbie buys 5 drinks, 3 burgers and 2 packets of chips. How much will this cost? She pays with a R50 note. How much change will she get?

TASK 2b – GUIDOS MENU

You have R300 to spend on 4 meals for a family.

Choose your meals and see if you have enough money.

If you can, work out how much change you would get from R300.

Guido's
Restaurant
SEAFOOD SPECIALS
Available daily from 11am till late

STARTERS:
Calamari Starter .... R 25
Mussels .... R 25

MAINS:
Hake .... R 35
Calamari Main .... R 45
Line Fish .... R 60
Kingklip .... R 65
Calamari Steak .... R 45
Sole .... R 55

PRAWNS:
12 Standard .... R 55
18 Standard .... R 70
24 Standard .... R 95
12 Queens .... R 99
18 Queens R145
24 Queens R190
6 Kings .... R 89

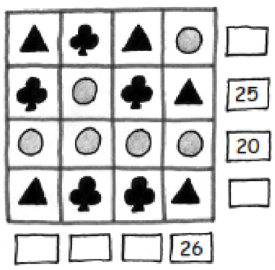
PLATTERS:
Platters for 1 .... R 79
Platters for 2 .... R145

PIZZAS:
Seafood Medium .... R 45
Seafood Large .... R 59

OTHER:
Seafood Pasta .... R 35
Calamari Burger .... R 39

All meals served with either Chips, Rice, Side Salad, Baked Potato or Veg
SPECIALS WILL BE REINTRODUCED WITH THANKS FOR ALL OUR LOYAL CUSTOMER SUPPORT

TASK 3 – SHAPE CODES



In this grid, each shape stands for a number.

The numbers shown are the totals of the line of four numbers in the row or column. Find the remaining totals. Say what number each shape stands for.

NB: This task was selected for analysis in the episodes that appear in Chapter 6.

I obtained permission from the class teachers to take the selected learners out of their classes during school time so that I did not have any issues with after school transport arrangements. As mentioned, to ensure that the learners were comfortable with this new scenario, I introduced the task-based interviews to the interviewees as a ‘mini club’. I also explained that the club ethos would be the same during the interview.

Selection of interviewees for task-based interviews

Interviews for *Luhlaza Primary* took place in July 2012. Two boys, Emi and Oma and two girls, Akhona and Kuhle were selected. Interviews for the *Elmtree Club* took place October 2012. I selected four learners from the club group in order to align with the data that I had from Luhlaza Primary. I selected two boys, Zac and Nate and two girls, Anathi and Thembela. As the interviews are intended to focus on just two learners at a time, I selected learners who I felt would be comfortable with having attention on them and comfortable enough to interact on a one-to-one basis with the other learner and with the facilitator.

Mellony Graven and I facilitated all four task-based interviews. The learners had met Mellony Graven (as a visiting mentor) on previous occasions and she also ran both clubs for me when I was away. I facilitated the task-based interviews for both pairs of girls and Mellony Graven recorded the video. Mellony facilitated for both pairs of boys whilst I recorded the video. The same tasks were presented in the same order in each interview which was about an hour in duration. After both sets of interviews, Mellony and I undertook a lengthy reflection session which was audio recorded thus providing me with additional data.

The primary source of data for the task-based interviews was video recordings supplemented by learner workings and post interview reflections between Mellony and myself. As indicated earlier, the task-based interviews consisted of three tasks. The entire video corpus available for analysis was thus over four hours in length. From this video corpus I transcribed and analysed Task Three in full for the boys and girls at Elmtree Prep and for the girls at Luhlaza Primary. I could not transcribe the boys' episode at Luhlaza Primary as the audio failed to record during the interview.

4.5 APPROACH TO ANALYSIS

> *Data analysis is a systematic search for meaning. It is a way to process qualitative data so that what has been learned can be communicated to others. Analysis means organizing and interrogating data in ways that allow researchers to see patterns, identify themes, discover relationships, develop explanations, make interpretations, mount critiques, or generate theories. It often involves synthesis, evaluation, interpretation, categorization, hypothesizing, comparison, and pattern finding (Hatch, 2002 cited in Leech & Onwuegbuzie, 2007, p. 564).*

This quote reflects the purpose and complexity of analysis in a research study. A summary of my analysis approach for this study appears in Table 12 below. I structure this section by taking each data collection instrument in turn and describing:

A. The analysis strategy used
B. The analysis framework or filter used
C. How the data will be represented in the reporting of findings

Table 12: Approach to Analysis summary

	Question 1: Evolving Mathematical Proficiency (Acquisition metaphor)		**Question 2: Nature of Mediation** (participation metaphor**)**	**Question 1 and 2**
Collection instrument	**Mathematical Proficiency (MP) Interviews One-to-one oral interviews**	**Fluency assessments**	**Task-based interviews**	**Reflective journals, learner work samples**
Analysis strategy	Basic statistical analysis	Basic statistical analysis	*Constant comparison:* for scaffolding practices and modes of interaction *Grounded approach:* for Attention Catching Mechanisms	Thematic analysis. Reading journals, looking for themes and qualitative data to support other analyses.

	Question 1: Evolving Mathematical Proficiency (Acquisition metaphor)		Question 2: Nature of Mediation (participation metaphor)	Question 1 and 2
Collection instrument	**Mathematical Proficiency (MP) Interviews One-to-one oral interviews**	**Fluency assessments**	**Task-based interviews**	**Reflective journals, learner work samples**
Analysis filter or framework	LFIN Mathematical Proficiency strand indicators for CU, PF and AR	Fluency elements: efficiency and accuracy	Modes of Social Interaction Attention Catching Mechanisms Scaffolding	
Representation of data in reporting of findings	Visual models (tables, graphs, figures) and descriptive narrative	Tables, graphs, figures and descriptive narrative	Transcripts, interactional description, descriptive narrative, still frames, tables	Descriptive narrative, photographs and figures to support other sources of data

The process of analysis makes use of codes, whether from an existing conceptual framework or from the data itself. Smagorinsky (2008) listed some concerns that many authors do not specify exactly how they arrived at the codes they have used for analysis, nor do they then subsequently use the codes when reporting on the findings. I have made a point in the sections below of clearly describing how I arrived at the codes used in this study. Furthermore, I have taken care in the reporting of findings to use the codes and indicators so that it is clear how the analysis has produced the findings.

In the sections below I expand on the analysis frameworks and filters used for each question in this study as shown in Table 12, namely the LFIN, fluency, modes of interaction, scaffolding, attention catching mechanisms and the ZPD.

4.5.1 ANALYSIS APPROACH FOR MATHEMATICAL PROFICINEY INTERVIEWS

For these interviews I used two different frameworks for analysis. The primary analysis framework for the MP interviews was drawn from Wright et al.'s (2006) LFIN framework. Supplementary filters are indicators that I summarised for the strands of procedural fluency, conceptual understanding and adaptive reasoning (Kilpatrick et al, 2001). I discuss each of these in turn.

Using notes written by the interviewers on the learner interview scripts during each MP interview on learner methods and actions and guidance from the relevant sections of Wright et al.'s (2006) book, I used the data to profile each learner onto the levels / stages of the LFIN. As the MP interview was carried out twice, I had a learner profile for each interview and was able to compare and contrast the two profiles to see possible change over time. The data is presented as descriptive narrative, in tables, using graphs and figures.

Learning Framework in Number (LFIN)

In this section I detail each LFIN aspect and the associated levels or stages, so as to illustrate how I determined where to position a learner on the LFIN using data from the interview. I specifically worked with a version of the LFIN that combines elements from Wright et al.'s 2006 and 2012 works. As noted earlier, the key aspects of the LFIN are:

A. Structuring numbers 1 to 20
B. Number words and numerals (including forward and backward sequences)
C. Conceptual place value knowledge (ability to reason in terms of tens and ones)
D. Early arithmetic strategies (strategies for counting and solving simple addition and subtraction tasks)
E. Early multiplication and division
(Wright, Ellemor-Collins, & Tabor, 2012; Wright, Martland, & Stafford, 2006)

Each of the key aspects of the LFIN are elaborated into a progression of up to six levels or stages with each model describing the characteristics of the levels or stages (Wright, Martland, Stafford, et al., 2006) which are detailed below.

ASPECT A: Structuring numbers 1 to 20

Counting strategies are regarded as a vital component of learners' early number learning because they can form an important basis for the further learning of numbers (Wright et al., 2006). Children also develop knowledge of simple additions, e.g. involving two addends in the range one to five, which does not rely on counting. According to Wright (2000, p. 706), although teaching children to provide answers immediately to questions might be regarded as habituated, recent research provides strong indications that teaching children to habituate simple addition facts through combining and partitioning small numbers can significantly facilitate the development of advanced arithmetical strategies such as non-counting-by-one strategies (Wright, et al., 2006).

Table 13: ASPECT A: Structuring numbers 1 to 20

Stage Number	**Stage Descriptor**	**Characteristics**
0	Emergent	Cannot immediately identify a quantity of 2
1	Instant	Recognises (subitises) a quantity of 2
2	Repeated	Recognises, describes and continues a linear repeated pattern of 2
3	Multiple	Creates a linear pattern of repeated units of a specified size
4	Part-whole to 10	Uses additive whole-part knowledge to 10. Knows number combinations to 10 and how many more are needed to make 10.
5	Part-whole to 20	Uses additive whole-part knowledge to 20. Knows number combinations to 20 and how many more are needed to make 20. Able to partition numbers up to 20.
6 [18]	Number properties	Understands the structural properties of numbers including how to regroup

[18] Note: although this aspect has 6 levels, the MP interview only asked questions up to level 4.

ASPECT B: Number words and numerals

This aspect consists of three sub aspects: i) numeral identification, ii) forward and iii) backward sequences.

i. Numeral Identification (NI)

Numerals are the written and read symbols for numbers. Learning to identify, recognises and write numerals is an important part of early arithmetical development (Wright, et al., 2006). Most children learn about numerals later than they learn about number words and number word sequences. They learn about numerals in almost the same way as they learn about letters of the alphabet. The term ‘identify’ in LFIN refers to the request to “state the name of a displayed number”. Table 14, below shows the model for numeral identification.

Table 14: ASPECT B: Numeral identification
(Source: Wright et al., 2006 p.12)

Level Number	Level Descriptor	Characteristics
0	Emergent	**Not able to identify** some or all 1-digit numerals
1	Numerals to 10 (One-digit numerals)	Able to identify **1-digit** numerals e.g. 5
2	Numerals to 20 (Two-digit numerals)	Able to identify **2-digit** numerals e.g. 34
3	Numerals to 100 (Three-digit numerals)	Able to identify **3-digit** numerals e.g. 452
4	Numerals to 1000 and beyond (Four-digit numerals)	Able to identify **4-digit** numerals and beyond e.g. 1025

Wright and his colleagues argue that determining children’s levels is straightforward based on whether a child makes errors or not. If a child makes no errors at all with two-digit numerals but makes an error with three-digit numerals, s/he will be judged to be at Level 2. Wright, et al. (2006), draw a distinction between counting and reciting a sequence of number words. While counting usually occurs in a problem-solving situation, merely saying a sequence of number words is not regarded as counting. Moreover children’s ability to say a sequence of number words is a prerequisite for developing the ability to count.

ii & iii Forward and backward number sequences

Forward and backward number sequences refer to the learners' ability to count a sequence of numbers forward and backward as well as being able to identify numerals (Wright, et al., 2006). To assess this, learners are presented with numbers and asked to start counting forward (e.g. 1 to 32) or to say the number that comes after "5". To be able to count on, children need to be able to say number word sequences correctly without missing any number. Table 15, below, shows the model for these sequences.

Table 15: ASPECT B: Construction of FNWS and BNWS
(Source: Wright et al., 2006 p.11)

Level Number	Level Descriptor	Characteristics
0	Emergent	**Not able to produce** Forward / Backward Number Word Sequence
1	sequences in the range 1 to 10	Able to produce the Forward / Backward Number Word Sequence from **1 to 10**
2	sequences in the range 10 to 100	Able to produce Forward / Backward Number Word Sequences in the **range 1 to 30**
3	sequences in the range 100 to 1000	Able to produce Forward / Backward Number Word Sequences in the **range 1 to 50**
4	sequences in the range beyond 1000	Able to produce Forward / Backward Number Word Sequence in the **range 1 to 100**
5	sequences in the range beyond 1000	Able to produce Forward / Backward Number Word Sequence in the **range beyond 100**

Determining children's levels in forward and backward number word sequence is straightforward, based on whether a child makes or doesn't make an error (Wright, et al., 2006; 2012). They add that it should be noted if the child seemed hesitant or was not fluent at any point in saying the sequence.

ASPECT C: Conceptual Place Value (CPV)

According to Wright, et al. (2006), learners do not initially construct ten as a unit composed of ones (only later are they able to see this) but are capable of solving addition and subtraction tasks involving two-digit numbers (from 10 onward) prior to their developing knowledge of the tens and ones structure. Table 16 below, shows the model used for the development of conceptual place value.

Table 16: ASPECT C: Conceptual place value
(Source: Wright et al., 2006 p.10)

Level Number	Level Descriptor	Characteristics
1	Initial concepts of 10 (ten as a count)	Not able to see ten as a unit composed of ten ones. The child solves tens and ones tasks using **a counting-on or counting-back strategy**. One 10 and 10 ones do not exist for the learner at the same time
2	Intermediate concepts of 10 (ten as a unit)	**Able to see ten as a unit composed of ten ones**. The child uses incrementing and decrementing by tens, rather than counting-on-by-one to solve uncovering board task. The child cannot solve addition and subtraction tasks involving tens and ones when presented as horizontal written number sentences
3	Facile concepts of 10 (tens and ones)	**Tens and ones are flexibly regrouped**. Ten is a unit that can be repeatedly constructed in place of 10 individual ones. Child is able to solve addition and subtraction tasks involving tens and ones when presented as horizontal written number sentences by adding and/or subtracting units of tens and ones

ASPECT D: Early arithmetic strategies

During the last three decades, the prevailing view of the teaching and learning of mathematics has shifted from being one of ‘transferring knowledge’ to one of ‘constructing knowledge’. Along with this shift, the importance of counting in the development of children’s strategies for solving number problems has been highlighted (Wright, et al., 2006). Table 17 below, shows the model for the stages in Early Arithmetical Learning that was consequently developed.

A necessary part of determining a learner’s strategies is to present tasks or situations that are problematic for him or her. In solving the problem the learner uses a current strategy or may construct a new strategy. The learner’s stage (from 0 to 5) in adding and subtracting 1 to 100 (or early arithmetical learning) is determined as shown in Table 17. Wright et al. (2006) consider this as the most important aspect of the LFIN.

Table 17: ASPECT D: Early arithmetic strategies
(Source: Wright et al., 2006 p.9)

Stage Number	Stage Descriptor	Characteristics (representing increasing levels of sophistication)
0	Emergent counting	**Cannot count visible items**. The child might not know the number words or might not coordinate the number words with the items
1	Perceptual counting	Can count only **visible** items starting from 1. Including seeing, hearing and feeling
2	Figurative counting	Can count **concealed items** but the learner will ‘count all’ rather than ‘count on’.
3	Initial number sequence	Initial number sequence. The child can **count on** rather than counting from one, to solve + or missing addends. May use the **counting down** to solve removed items. (count-back-from)
4	Intermediate number sequence	**Count-down-to** to solve missing subtrahend (e.g. 17-3 as 16, 15 and 14 as an answer. The child is able to use a more **efficient** way to count down-from and count down-to strategies (count-back-to)
5	Facile number sequence	Uses of range of **non-count-by one strategies**. These strategies such as compensation, using a known result, adding to 10. Commutativity, subtraction as the inverse of addition, awareness of the 10 in a teen.

ASPECT E: Early Multiplication and Division

While early arithmetical strategies form the central structure of the framework, Wright et al. (2006) argue that other aspects such as multiplication and division should not be seen as compartmentalised or be developed in isolation. This model includes contributions by Mulligan (1998), which inform Wright et al.'s (2006) model for focusing on young children's strategies in multiplication and division. Table 18 below shows the model for development of early multiplication and division.

Table 18: ASPECT E: Construction of multiplication and division strategies (Source: Wright et al., 2006 p.14)

Level Number	Level Descriptor	Characteristics (representing increasing levels of sophistication)
0	Initial grouping and perceptual counting (Forming equal groups)	Able to model or share by dealing in equal groups but not able to see the group as composite units; **count each item by ones.**
1	Intermediate composite units (Perceptual multiples)	Able to model equal groups and counts using rhythmic, skip or double counting; counts by ones the number of equal groups and the number of items in each group at the same time **only if the items are visible**.
2	Abstract composite units (Figurative units)	Able to model and counts **without visible items** i.e. the learner can calculate composites when they are screened, where they are no longer rely on counting by ones. The child may not see the overall pattern of composites such and "3, 4 times".
3	Repeated addition and subtraction	Co-ordinates composite units in **repeated addition and subtraction**. Uses a composite unit a specific number of times as a unit e.g. 3 + 3 + 3 + 3; may not fully co-ordinate two composite units.
4	Multiplication and division as operations	**Two composite units are coordinated abstractly** e.g. "3 groups of 4 makes 12"; "3 by 4" as an array
5	Know multiplication and division facts strategies	**Recalls or derives easily, known multiplication and division facts;** flexibly uses multiplication and division as an inverse relationship, is able to explain and represent the composite structure in a range of contexts.

This model consist of *six* levels of multiplication and division knowledge, as described in order of increasing sophistication. The development of multiplication and division as operations relies on the learner's ability to co-ordinate composites, i.e. to use groups of equal groups as single entities.

Additional indicators for procedural fluency, conceptual understanding and adaptive reasoning

Mathematical proficiency is a key construct for research question one and for broader work in the SANC project. In order to link learner mathematical progress to Kilpatrick et al.'s (2001) strands of mathematical proficiency, I drew on their work to find broad indicators to guide observations I made for each learner from their MP interview scripts. This search resulted in my summarising the indicators for *conceptual understanding, procedural fluency* and *adaptive reasoning*. *Strategic competence* and *productive disposition* are not included because although the MP interview does include some tasks that are number stories (see Tasks 13 and 14 in Appendix B), these tasks did not reveal enough about strategic competence to enable analysis of learners' proficiency in this respect. The number stories are simply word sums, which the learners need to make sense of within the confines of interview process. Therefore, I have not considered strategic competence in my observations. Neither have I included the productive disposition strand, as this is not a specific focus for my study and is therefore not assessed in either of the instruments used[19].

These are the indicators that I looked for whilst analysing data from the MP interviews:

- *Conceptual understanding*: ability to use multiple representations, estimating, making connections and links and understanding properties of number systems (i.e. number sense).
- *Procedural fluency*: ability to solve a problem without referring to tables and other aids, using efficient ways to add, subtract, multiply and divide mentally and on paper, understanding when it is appropriate to use procedures or not (as not all calculating situations are alike). In addition, as discussed previously in Chapter Two, I looked at "elements of fluency" which includes knowing basic facts and knowing basic methods (Askew, 2012a, p. 55).
- A*daptive reasoning*: being able to give informal explanations and justifications for one's work, intuitive reasoning based on pattern, thinking logically about the relationships amongst concepts and determining whether the use of

[19] Productive disposition is examined in other research studies carried out by the SANC project. See for example: Graven, Hewana & Stott (2013) and Graven (2012).

a particular procedure is appropriate or not for the context i.e. being able to adapt the problem solving approach to the context.

These indicators for conceptual understanding, procedural fluency and adaptive reasoning and the structure of the LFIN provide the analysis framework, tools and language to discuss learners' mathematical proficiency for the data collected from the MP interviews. I now look at the analysis strategies used for the fluency assessment data.

4.5.2 ANALYSIS APPROACH FOR FLUENCY ASSESSMENTS

I used the scores from the fluency assessments to profile each learner in terms of efficiency and accuracy. As these fluency assessments were carried out twice, I had a learner profile for each set of assessments. I was able to compare and contrast the two profiles to see if there was change over time. The data from this instrument is presented as descriptive narrative, in tables, graphs and figures.

My focus was on developing two elements: efficiency and accuracy. I thus used efficiency and accuracy as the analysis filter for working with the fluency assessment data. The results from these activities showed the speed the learner worked at and how accurate that working was. Each fluency activity therefore provided three different scores:

1. **Actual mark**: number of answers the learners got right in the activity. A simple overall mark out of total possible marks
2. **Completion %**: number of answers the learners actually completed
3. **Accuracy %**: number of correct answers out of those completed

Specifically, the *completion* and *accuracy* percentages allowed me to track 2 things:

- The *speed* (or how *efficiently* the learners were working) at which they are answering in the given time period (a *completion rate*)
- The *accuracy* of their work in that time (an *accuracy rate*)

Consequently I was able to compare these scores and rates when the activity was re-administered again, to see where the progress was coming from. After the second round of assessments, it was possible to see if learners completed more or the entire activity (i.e. 100% completion) but were not accurate with that speed, or if learners did not complete the whole activity, but what they completed they got all right (i.e. 100% accuracy).

On its own, the completion rate does not give a complete picture of the learner's efficiency in working as they may well guess at an answer, which would then give them a low accuracy rate. It was important then, to review both the completion and the accuracy scores together to get a meaningful picture of the learner's progress over time. I illustrate this using an example of the doubling activity for Zintle in Elmtree Prep club. These are Zintle's scores following the first fluency assessment.

Zintle: March 2012 Activity Name	Activity out of ..	Number Correct (& score)	Number Answered (Completion %)	Number correct from those completed (Accuracy %)
1st Doubling activity	17	7 (7 out of 17 = 41%)	8 (47%)	7 (7 out of 8 correctly answered 87.5%)

Zintle got 41% for the doubling activity as she only completed 8 questions (or 47% of the activity) in the given time. Of those 8 questions, 7 were correct, giving 87.5% accuracy. This gives a different perspective to her 41% overall score.

Zintle: July 2012 Activity Name	Activity out of ..	Number Correct (& score)	Number Answered (Completion %)	Number correct from those completed (Accuracy %)
2nd Doubling activity	17	16 (16 out of 17 = 94%)	17 (100%)	16 (16 out of 16 correctly answered 100%)

In a second use of the same activity in July, Zintle got 94% overall, answering all 17 questions. Her completion rate doubled and her accuracy rate increased by 12.5% from 87.5% to 100% in answering 16 of those 17 questions accurately. This indicated some progress in her accuracy and efficiency in doubling over time.

4.5.3 ANALYSIS APPROACH FOR TASK-BASED INTERVIEWS

> *Accessible video technology provides researchers with a powerful "microscope," greatly increasing the interactional detail that can be recorded and permanently stored for comprehensive analysis and reanalysis by multiple investigators. However, this enhanced observational power requires thoughtful attention to the problem of* **how** *to extract data and meaning from complex video-based corpuses (Goldman, Erickson, Lemke, & Derry, 2007, p. 15).*

In this introduction I document how I addressed the challenges referred to in this quote. Erickson (2006 in Barron & Engle, 2007) states that video records are not data but "resources for developing data" (p. 25). In other words, carefully selecting segments of video from the corpus and using them for a specific analytic purpose creates data. The strategies I used for selection of data from the video corpus became important and are articulated here.

With approximately four hours of task-based interview data, I searched for ways to select particular parts of it for in-depth analysis. To select which video segments were brought into focus for this part of my study, I used the *deductive* approach (Goldman et al., 2007) as I had a strong theory and clear research questions and this approach involves "systematically sampling from it [video corpus] to examine specific research questions" (p. 22). This approach was applicable to my study in that I specifically chose to create my video corpus in the task-based interviews and systematically selected samples from it in order to address research question two. The rationale for the video samples I selected is discussed in the introductory section of Chapter Six.

Terminology and transcription conventions used in the task-based interviews

For this study, I use the following terminology to refer to selected video segments. Video segments represent *episodes*. Selection determines which episodes are brought into focus for deeper analysis. An episode can be broken down into segments or *events*. An event will represent a key point in a larger episode. Figure 10 reveals the relationship between these items for this study:

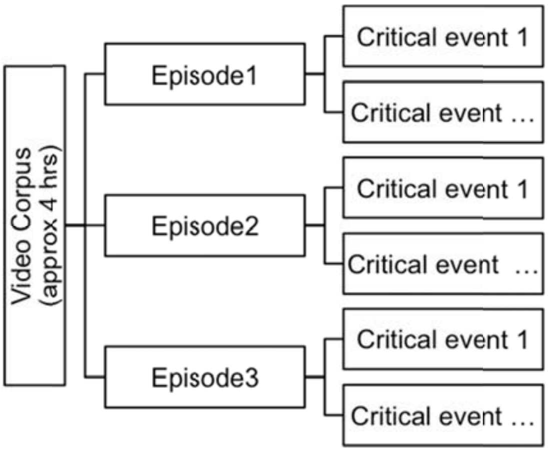


Figure 10: Relationship between video corpus, episodes and critical events for this study

Initially, all the speech and interactional data from the task-based interview video was transcribed by a transcriber. After viewing the entire video corpus myself, I identified key episodes and extended the transcription based on the analysis strategies I used for this data as described below. In subsequent detailed transcription of selected events and episodes from the video corpus, I used certain conventions as summarised in Table 19 below.

Table 19: Transcript conventions used in this study

Line	When the speaker changes (or a participant does something), a new line number is allocated
What is said	Spoken words
[What is done]	Description of physical actions: e.g. [*shakes head up and down*], [*touches board with index finger at equation*], [*nods yes*], [*indicates equation*] Specific people addressed by an utterance, especially if not to all who are present: [*to John*], gaze or body direction: [*looking at Marcia*], [*facing board*], laughter, giggling and so on
Unheard words	[inaudible]

Descombe, (2010) suggested representing and presenting large volumes of video data in findings can present some challenges. Two of his suggestions are important to this study. First, it is not feasible to present *all* of my data; rather I have carefully selected the parts of the data that I need to present particularly those that originate from the video corpus. Denscombe (2010) cautions that extracts from transcripts are unlikely to provide *proof* of a point but rather serve as *illustrations* of a point and supporting evidence for an argument. Secondly, I therefore acknowledge that the extracts included in the findings chapters do not count as evidence, rather they provide "an illustration of a point that is being made" (Denscombe, 2010 p. 295).

Barron and Engle (2007) warned that "the problems of re-representing the complexities in video are not trivial" (p. 32) and proposed that a narrative approach using multiple methods of representation can broaden the acceptance of analysis originating from video data. Following their advice, findings presented for the task-based interview video data are presented as narrative descriptions and are supported by transcripts showing *verbal* speech and *non-verbal* interactional descriptions (such as gestures, tone, facial expression etc.) in an attempt to portray a fuller picture of interaction from the video.

I used two analysis strategies to analyse different aspects of the task-based interview data set: *constant comparison* and a *grounded approach*. I used constant comparison analysis as the strategy for working with modes of social interactions (Bourne and Jewitt, 2003; Lemke, 2012) and Anghileri's (2006) scaffolding practices. A grounded approach was used to work with Meira and Lerman's (2009) notion of catching attention. Below, I explain each of these in turn.

Constant comparison for scaffolding (mediating) practises

Leech and Onwuegbuzie (2007) pointed out that when a researcher wants to identify underlying themes presented through a data set, a *constant comparison analysis* can be helpful. I used a *deductive* approach (e.g., codes are identified prior to analysis and then looked for in the data) with this strategy.

I added a column in a spreadsheet for *mediating practice*. I printed the transcript and Anghileri's framework and watched the selected video. In the first instance I noted what was being done and observed to see if the mentor used a mediating practice that was in Anghileri's framework. If so, I noted the practice and the level of scaffolding from her hierarchy. An example of this is shown in Figure 11 below. The numbers in the brackets following the mediating practice indicate her hierarchy level (i.e. 1, 2 or 3).

Line no	Participant	What is said and what is done	Mediating Practice
44	DEBBIE	So this twenty six is also adding up here	Clarifying (2b)
45	ANATHI	Ja ***[at the same time]***	
46	DEBBIE	to make twenty six	
47	THEMBELA	***Looks at Debbie briefly***	
48	DEBBIE	And this here, if you add these things up, will make?	Prompting (2b)
49	DEBBIE	***Debbie points to second row of the chart***	
50	THEMBELA	25?	
51	THEMBELA	***Looks at Debbie***	
52 53	DEBBIE DEBBIE	25. Okay? Okay, so what are these things? ***Debbie indicates the symbols on the chart***	Clarifying (2b)

Figure 11: Sample coding from transcript for mediating practice

As I noted the mediating practices, I found some practices not present in Anghileri's hierarchy and conversely some of Anghileri's that were not evident in my data. I compiled a list of those practices that were evident in my data, thus extending Anghileri's hierarchy. Examples of other practices observed include: orienting, excavating and seeking justification. For these additional indicators, I drew on the DEST list of scaffolding practices reviewed in Chapter Two (Victoria Department of Education and Early Childhood Development, 2004). The practices and the full list of practices used for coding and analysis in this study are shown in Appendix F. Additional indicators drawn from the DEST list are clearly marked in this list.

Constant comparison for modes of social interaction (non-verbal data)

I also used the *constant comparison* analysis strategy to analyse the *nature of the social interactions* across the selected video episodes as a *whole.* I realised that is was important that my transcripts captured what all participants were doing at a particular moment in time, so that individual responses to particular mediation could be tracked. Thus it was important that I looked at a whole range of social interactions in the video and not just speech, thereby considering both verbal and non-verbal aspects. As Gresalfi (2009) pointed out in her analysis of video data, both speech and other interactions:

> *were necessary to understand individual students' role in the unfolding conversation, as students can follow a conversation without speaking and can speak aloud without looking at any one person* (p. 337).

Although video data is not particularly suited for capturing thoughts, attitudes and feelings, it contains a wealth of visual information "on gaze direction, facial expression, pointing and other gestures, contextual artefacts referred to in the verbal text, positional grouping, relative distances and directions" (Lemke, 2012, no page) which can be termed *non-verbal data*.

To this end, I used an existing analytic framework with a series of codes which were added to each utterance based on Bourne and Jewitt's (2003) multimodal analysis of social interactions. They employed four codes, which included: *speech* (verbal speech), *posture* (including body movements such as dancing, throwing arms into the air etc.), *gaze* (looking and glancing at each other, direct eye contact between participants) and *gesture* (using hands to do something i.e. pointing to something, touching), which I applied to my video transcripts. Based on what I saw in my video data I added two further codes: *expression* (including laughter, frowning, nodding etc.) and *mathematical action* (mathematical writing, workings on paper, calculating using fingers or on paper etc.).

I trialled this coding on one section of my transcript and noted the increased clarity it gave me. I was able to group a selection of utterances by participants into what I call a '*turn'*, which I describe as a communicational unit of analysis that encapsulates the social interactions that arise in the activity[20]. From these turns I was able to identify '*critical*

[20] This term arose from a discussion with Steve Lerman when we were reviewing my video transcripts in July 2013.

turns' that reflected significant moments in the episode and *critical events* which demonstrated a significant or contrasting change from previous understanding or a conceptual leap from earlier understanding in the participants (usually the learners). More importantly (as noted in my research journal), this level of coding enabled me "to see more clearly the relationship between catching attention and mediation" (14^{th} July 2013) and was the breakthrough I needed for connecting attention catching and mediation. In addition, the coding suggested ways to code for attention catching. An example of a turn is illustrated in Table 20 below. In this turn (turn 21), there is more *non-verbal* data (gesture, expression and posture) than *verbal* data (speech).

Table 20: Sample of coding modes of social interaction

Turn	Participant	Mode of social interaction	What is said and what is done
21	ANATHI & THEMBELA	GESTURE	*Thembela points her pencil to chart as she thinks; Anathi appears to be thinking*
	THEMBELA	EXPRESSION / POSTURE	*Thembela takes a breath, stretches and smiles*
		SPEECH	I think *[first two words spoken slowly]* the triangle is going to be eleven. That's what I think.

I subsequently coded all the selected transcription episodes for analysis. I used a spreadsheet function to count the codes for each participant in the interview (although I am not in any way attempting to undertake a discourse or semantic analysis of the data as this is not the focus of my study). The count function allowed me to note the recurring *types* and *range* of interactions for each participant in the task-based interviews.

Grounded approach for attention catching mechanisms (ACMs)

As Meira and Lerman’s (2009) work does not provide a comprehensive list of indicators or codes for catching attention, a different analysis strategy was necessary for working with this notion. Therefore I took a *grounded approach* and reviewed the data without preconceived codes or indicators in mind. I looked for instances in the interactions between participants where they seemed to catch each other’s attention, for whatever reason. As I watched, I coded the instances as emergent ACM codes for attention catching: for example, touching a learner on the shoulder, eye contact between participants etc.

After coding for the mode of social interactions, I watched the video again, and created codes and categories of ACMs using the emergent codes as a departure point. I expanded on my emergent codes to flag when a learner’s attention was caught by the mentor or when the mentor’s attention was caught by something the learners did or said. Once I had a workable list of ACM codes I extended them to indicate whose attention had been caught. The final codes and categories, along with some examples from the selected video data are shown in Table 21 below. Once I had these codes I was able to apply them to the transcript, using another column in the spreadsheet called *attention-catching mechanism.* These sequences are presented and analysed in Chapter Six.

Table 21: Attention catching mechanisms: final codes used in this study

Attention Catching Mechanism (ACM)	Whose attention can be caught?	Examples observed from video data
Breath emphasis	Mentor Other learners	Drawing in of breath, sighing, breathing out (often with sound effects)
Posture & expression	Mentor Other learners	Lifting hands over head, shaking head, frowning, laughing, smiling, leaning in and out, rocking in chairs, nodding
Touch	Mentor Other learners	Physically touching a person on shoulder, arm, hand or head
Exclamation	Mentor Other learners	Verbal exclamations such as “WOW”, “YOH”, “OOOH”, “OKAAY”, “GO, GO”
Eye contact:		
Mentor to learner M ➔L	Learner	
Learner to mentor L ➔M	Mentor	
Learner to learner L ➔L	Other learners	
Mentor:		
Action	Learners	Mentor presents one of the learning activities to the learners, writing or drawing something
Question	Learners	Mentor directs a question to the learners
Gesture	Learners	Pointing to something, indicating a learner
Statement	Learners	Mentor makes a statement
Learner:		
Action	Mentor Other learners	Learner writing something or makes a mathematical action such as counting on fingers etc.
Question	Mentor Other learners	Learner asks a question (to mentor or other learner)
Gesture	Mentor Other learners	Using hands expressively, gesticulating, pointing to something
Expressing something	Mentor Other learners	Expressing an opinion, saying something mathematical, giving an answer

The flow chart in Figure 12 below summarises the process of analysis I undertook for the selected video episodes. Using the basic transcription data (speaker, what is said and done), I first coded for *social interactions*, then for *attention catching mechanisms* and finally for *mediating practices*. Each of these coding structures produced data that could be counted. From these counts, percentages were worked out and matrices or graphs produced. Specifically, from this data I produced matrices showing:

- The types and frequencies of *modes of the social interactions* that took place between the participants
- The types and frequencies of *attention catching mechanisms* observed
- The types and frequencies of *mediating practices* that the mentors used in the episodes

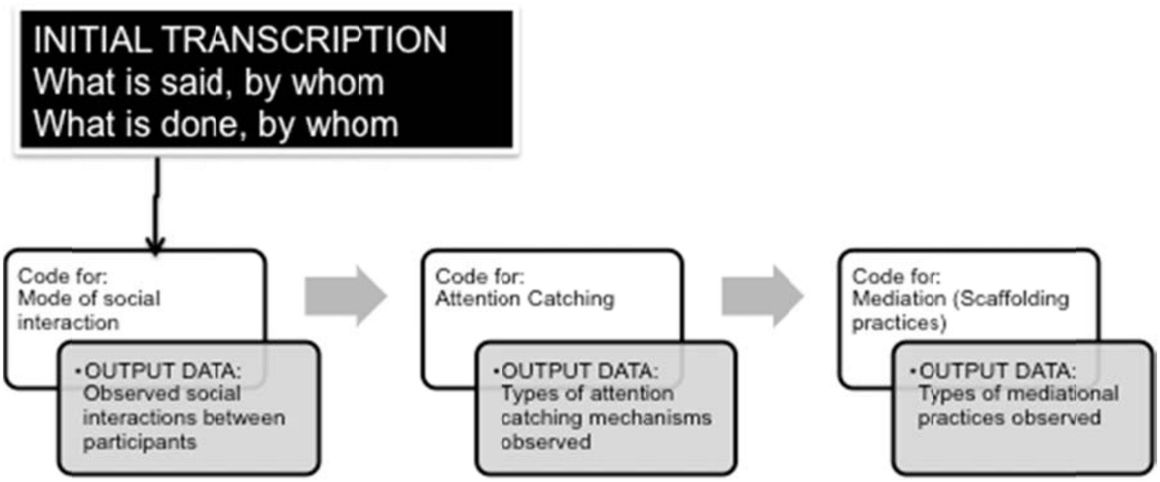


Figure 12: Flow chart for the process of analysis of selected video episodes used in this study

Lerman (2014) pointed out that it is the researcher's job to draw on the "observable material in constructing an account of learning" (p.22). It is therefore the researcher's undertaking to make sense of the observable material from video, journals etc. and to find ways to categorise it and present it to the reader. To this end, I expand upon two key filters or frameworks for the task-based interview data collected for question two: firstly Meira and Lerman's (2009) notion of catching attention and secondly Anghileri's (2006) scaffolding model described in Chapter Two.

Meira and Lerman (2009) linked the emergence of a ZPD as dependent on participants catching each other's attention. Lerman asks how we can make sense of catching of attention in “individuals negotiating their relationship with the learning environment and the people in it” (Lerman, 2012, p. 2) and how can we make it observable for analysis. I used Meira and Lerman’s (2009) notion of catching attention as an analysis filter, and I approached this using a grounded approach. As described above I created my own analysis framework (since Meira and Lerman do not provide one).

For scaffolding practices, the Anghileri (2006) model is extensive and proposes “three levels for scaffolding” (summarised in Figure 13 below) which establish a range of effective teaching strategies that may or may not be apparent in mathematics classrooms. These are discussed briefly below.

- *Level 1 practices: Environmental provisions*

  Learning can take place through interactions with various environmental provisions but *do not involve direct interactions* between the teacher and learners (e.g. classroom organisation, artefacts, self corrected tasks etc.). These environmental provisions are not always seen as scaffolding practices.

- *Level 2 practices: Explaining, reviewing and restructuring*

  These involve *direct* interactions between the teacher and learners and are related specifically to the mathematics under consideration. ‘Traditional’ scaffolding practices tend to be evident at this level.

- *Level 3 practices: Developing conceptual thinking*

  This level consists of interactions that *explicitly* address the development of *conceptual thinking* in learners and which she observes are often lacking in classroom interactions .

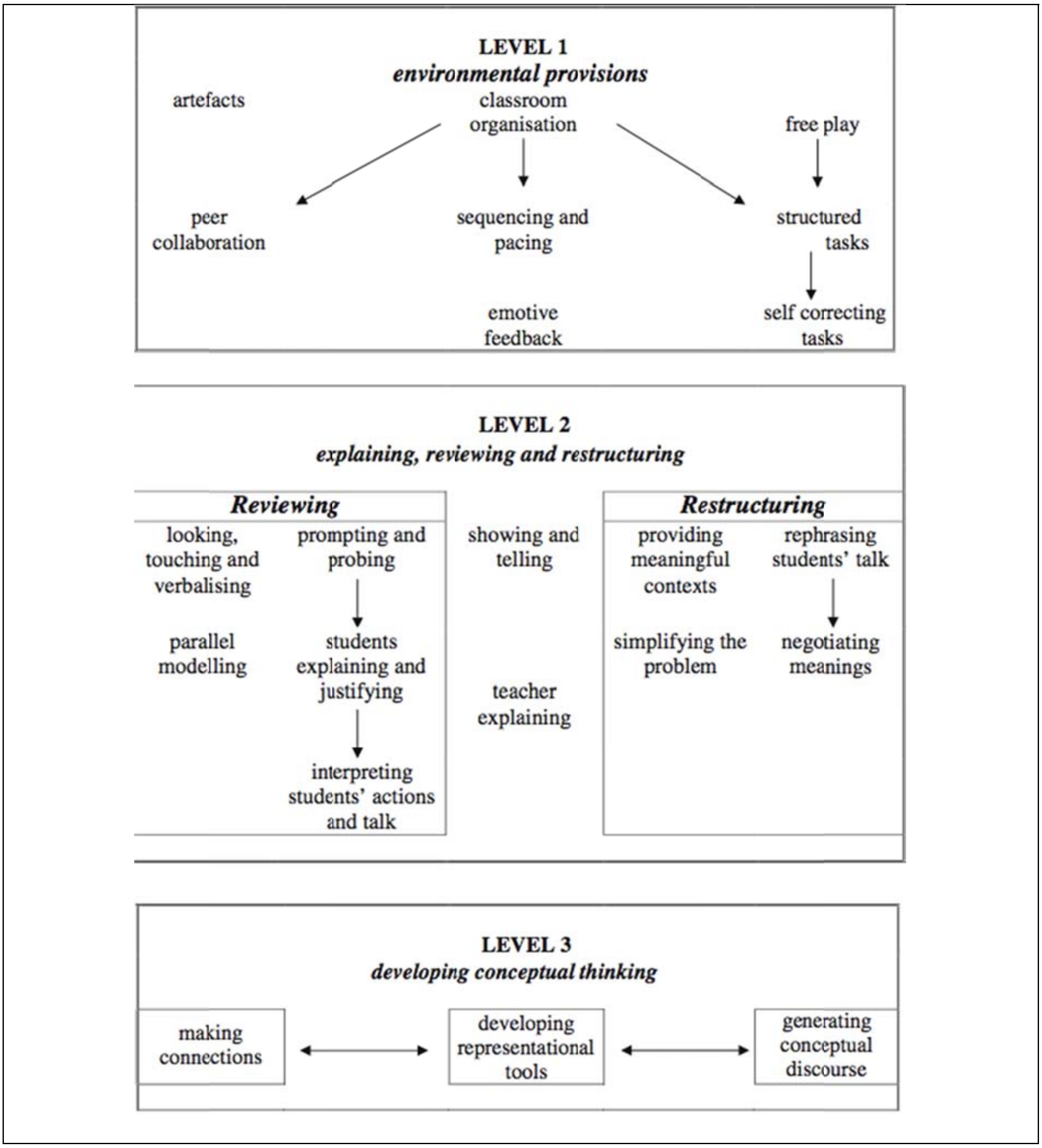


Figure 13: Teachers strategies for scaffolding learning (Anghileri, 2006 pp.39-41)

Having completed the description of the approaches used for analysis in this study, I now turn to discussing methodological successes, tensions and dilemmas that arose during the study.

4.6 METHODOLOGICAL SUCCESSES, TENSIONS AND DILEMMAS

When I began my PhD study, my supervisor recommended that I keep a research journal. Following the pilot, this became a significant data collection tool. It would not have been possible to write this chapter in the reflective way that I have without drawing on the entries in my research journal. Through the course of my study I made a point of writing in the journal frequently and it became a habit to do so after weekly club sessions, after reading literature, after working on data, after supervisory sessions, when grappling with a theoretical issue, when writing papers and conference presentations and so on. I also used my journal to sketch the many diagrams I use in this study as these diagrams helped me to make sense of many aspects of my work. The entries were invaluable when it came to remembering the stories, the personal learning process, the decisions I made and why and how aspects of the research evolved. Ultimately the entries enabled the reflexive praxis I discuss below.

As I have discussed in earlier chapters, I play multiple roles in the SANC project and wore multiple hats during this research study. At the start of the research process it was possible that these multiple roles could have caused tension. To that end I used my reflective journal to document as much about how the roles impacted on each other and on the process of research. Graven wrote about her own experiences in a similar situation and stated that the "theoretical tension was turned into a research advantage" (Graven, 2004). She explained further:

> *I was expecting some tension to emerge in relation to my role as an 'INSET co-ordinator' and my role as 'researcher.' Instead I discovered a powerful* ***praxis*** *[emphasis added] in the duality of being both INSET worker and researcher. My own learning in terms of becoming a more experienced 'INSET provider' was maximised by the ongoing reflection, which was stimulated by the research* (Graven, 2002, p. 2).

For me '*praxis*' is a way of doing things or a way of translating theoretical ideas into action. This gave me a new way of looking at my roles and how those roles interacted with each other. For Graven, the dual role gave her a number of advantages: it enabled a form of action-reflection practice, gave form to her research and the process, the on-going reflection was stimulated by her research and her own learning was maximised by the on-going reflection. These insights encouraged me to be aware of how multiple roles might bring a powerful praxis to my research project. By being aware of these insights before I started this research, I was able to make the most of the opportunities presented by these differing and challenging roles.

From a Vygotskian perspective, data generated through the research process is a social construct developed through the relationship of the researcher, research participants, the research context and the methods of data collection (Smagorinsky, 1995). Smagorinsky (1995) stated that researchers need to reflect on how their involvement in the research process affects teaching, learning, and the evaluation of both. Drawing on these comments, I argue that in my case, the relationship between the researcher and the research context (the clubs within the SANC project) is a highly complex one. Nonetheless it is one that allowed me to reflect not only on how the research process affected teaching and learning in the clubs but also on how the research process affected me as researcher and the context in which I operate. In the following paragraphs I illustrate how my triple role enabled an on-going, powerful reflexive practice to develop between the club learning programme design, mentoring in clubs and my research with reference to Figure 14 which illustrates this triple role diagrammatically.

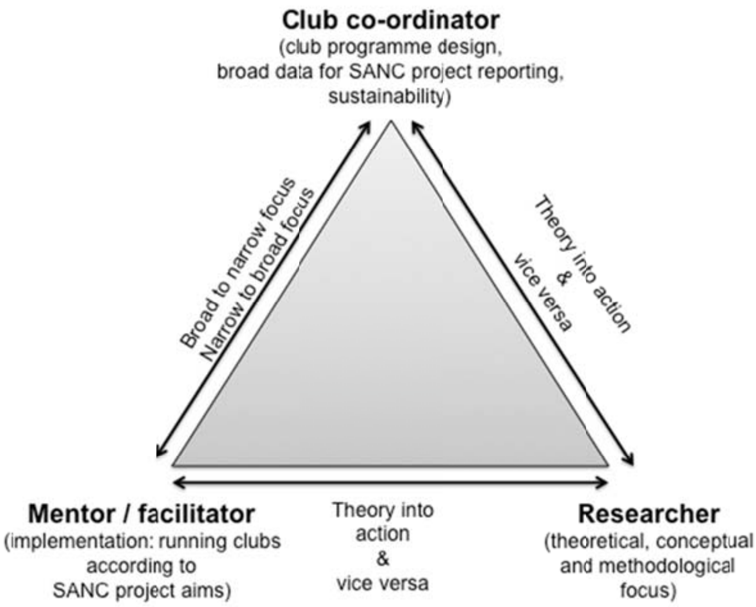


Figure 14: Diagrammatic representation of my triple role in maths clubs

In my role as club co-ordinator and programme designer, I had the opportunity to translate a theoretical or methodological idea from the research literature into action. One example of this was the introduction of reflective fluency activities into the Elmtree Club, inspired by Askew's (2009) suggestion discussed earlier in this chapter. Another example was using the five strands of mathematical proficiency (Kilpatrick et al., 2001) as the key framework for the study, translated into action, as the development of these strands became the key driver in selection of activities promoted in the clubs. Conversely, this practice enabled translating action into theory or in extending an existing concept. For example, I initially generated the MP interview scores as a way of generating quantifiable data in order to report on club progress in the SANC project's annual reports to be able to compare my two case study clubs. I developed ways to fit these into the LFIN framework, thus developing an extension of an existing concept from a theoretical and analytical point of view.

I briefly provide an example where all three roles influenced each other. Mellony Graven's and my experiences in the pilot brought to light the entwined and dialectical nature of the data collection and design processes and the significance of the post-club reflection sessions as a powerful data collection instrument for planning the club sessions. Furthermore, through the pilot we identified and shaped the zone of proximal development for the purposes of our club as the critical design concept for each club session for each learner. In addition, the pilot influenced the broader study leading to an increased focus in my research questions and thus the theoretical and conceptual frameworks. This reflective praxis illuminates the relationships between theory and practice and how the dialogue between the two elements informs each. We used empirical evidence to move from an initial multifaceted design to a much simpler, more learner-centred design and these findings informed the data collection process and the club session design for this research study.

The second major instance I highlight is in terms of myself as a researcher acting as an agent of change[21]. As I have argued, the clubs enable a powerful praxis between research and development. For myself (as club mentor and researcher), using findings and data from the clubs enabled myself and other SANC project team members to feed these experiences directly into in-service courses such as the B.Ed and M.Ed programmes and into our project's teacher development programme (NICLE).

[21] This notion of clubs as 'agents of change' is further explored in a paper presented at the 2014 SARAECE national conference.

Tensions and dilemmas

For research question two, I originally planned to collect video data in every club session. However, looking at the early video data collected, I realised that it would not be suitable for analysis purposes. The first obstacle was that as the club mentor I could not collect video data at the same time as being a participant in the club. On realising this, I asked a number of colleagues to assist me in taking video data during club sessions.

However, upon viewing the data recorded in this way, I encountered a key obstacle: lack of focus on learners faces, gestures, speech, activities or events of any significant duration. There were numerous reasons for this. Many of my club sessions took place on the carpet thus much video showed tops of heads and little else. Additionally, learners in the clubs often spoke softly and with the background noise of other learners I could not make out what was said. Also, learners were highly mobile making videoing difficult. I realised that this video provided data with regard to the structure of club sessions, the socio-mathematical norms I was promoting, the pace of the sessions and some beginnings of data showing more positive mathematical learning dispositions amongst learners in the clubs (Research journal entry, 3 July 2012) but did not provide data that zoomed into the mediation or emergence of ZPDs. This was a central problem for my research given my second research question was focused on mediation.

To find a way forward, I selected a number of video excerpts from this early data set and shared them with Prof Lerman[22]. We discussed the issues I had encountered and he agreed that another approach would be necessary. Subsequent discussions with my supervisor led to the idea of recording mediation of club activities with pairs of learners in a noise free environment. Thus the idea of task-based interviews as a way of collecting rich video data for question two emerged. The methodological approach I used for these task-based interviews has been discussed earlier in this chapter.

Other challenges involved the *logistics* of finding time to do the data collection in the schools with learners from both clubs. One of my concerns was not to use too much of the school day by taking learners out of the classroom. I addressed these issues as follows. For the MP interviews, I trained other SANC project team members to administer the interviews

[22] SAARMSTE Research School 2012

which allowed four or five learners to be interviewed simultaneously for an hour each whilst the school was in assembly. For the task-based interviews I asked permission from the school principals and the class teachers to take the learners out of class for one hour. The teachers chose times when learners would not miss out on too much class work.

Another challenge involved the great *quantity* of data I had collected. The data for question one was easier to deal with as the results for both the MP interviews and the fluency assessments could be entered into spreadsheets following collection. Once the initial structure of the spreadsheet was set up to generate scores, data was readily available for presentation and analysis when the time came. I completed the data entry after every instrument was administered. However, profiling the learners after the first and second interviews onto the LFIN profile was left until later.

As discussed above, I initially video reordered every club session until July 2012 (two a week, for approximately one hour each). This was a large video corpus to review and organise, and was at times overwhelming. Some of this video had been transcribed[23] for use in this study. After deciding to undertake task-based interviews, I had another four hours of video to transcribe and review. I was fortunate that the initial transcription of the task-based interview video corpus was done in its entirety by a professional transcriber. However, I did the subsequent re-transcription that involved checking the initial transcript against the video and splitting it into lines for the non-verbal data analysis. Once this was complete, I was able to code and analyse the data myself. By using a deductive approach for selecting video segments from this video corpus I was able to reduce the data for my study, thus bringing particular events into focus for deeper analysis.

Finally I discuss an *ethical tension* that arose during the use of the timed fluency activities. As a way of dealing with the ethical tension of using these activities, I devised and piloted a supplementary mechanism for the learners to reflect on their own progress in these fluency activities in the Elmtree Prep club. In Chapter Five, I illuminate the opportunity that such timed activities could offer by sharing the story of one learner's experience with the timed fluency activities and the supplementary reflection activity.

Closing remarks for this section

[23] Transcription conventions used in this study are documented in both the Methodology chapter (Chapter 4) and Chapter 6.

The methodological dilemmas I faced during the course of my study tell a story of my learning process through this study. They highlight reflection as a powerful part of the learning experience for myself as a researcher. In the next and final section of this chapter I review the ethical aspects of this study and how I have addressed authenticity concerns.

4.7 ETHICS AND AUTHENTICIY OF THE RESEARCH

Ethical permission from Rhodes University and from the Eastern Cape Department of Education was obtained through the usual procedures. Working as I did with young learners in the mathematics clubs, I obtained informed parental consent written in the appropriate home language in the form of signed letters which explained the research and the anticipated learner involvement. In addition I obtained teacher, principal and district permission for each school and class that allowed learners to participate in the mathematics clubs. As the learners were recorded via journal notes, video and audio recordings, learner pseudonyms have been used in subsequent publication of data and in this thesis and school names have been changed. Club participation was always voluntary. Learners were able to leave the club at any time if they, their teacher or parent wished them to do so. A sample parental consent letter and ethical permission are included in Appendix L.

Denscombe (2010) stated that conventionally, the credibility of a research study has been judged on validity, reliability, generalisability and objectivity. However, due to the nature of qualitative research, many agree (Cohen et al., 2000; Denscombe, 2010; Onwuegbuzie & Leech, 2006) that it is not feasible and is indeed problematic to judge and verify qualitative research according to these criteria.

Reading related literature on this issue, one primary reason that it is not feasible to judge on these criteria is that it is “virtually impossible to replicate a social setting” (Denscombe, 2010, p. 298). Another reason is that the researcher is normally “intimately involved in the collection and analysis of qualitative data … that the prospects of some other researcher being able to produce identical data and arrive at identical conclusions are equally slim” (Denscombe, 2010 p. 298). Thus Denscombe (2010) argued that rather than abandoning criteria for judging qualitative research in conventional ways, many researchers take a more pragmatic approach to verification.

These ideas resonated with my own theoretical and methodological approaches for a number of reasons. As I have mentioned previously, the Vygotskian perspective presupposes that the research (including the data and results) is socially constructed and that the results can never be ‘pure’. Moreover, the interpretive paradigm recognises that research is primarily to “understand the subjective world of human experience” (Cohen et al., 2000, p. 22). From this point of view, it is inappropriate to apply positivist criteria to one’s study. Maxwell (1992, cited in Cohen et al., 2000) argued that in qualitative research there is a need to replace positivist notions with the notion of *authenticity* suggesting that “understanding” is a more suitable term than validity in qualitative research (p. 106).

Using a social approach, Denscombe (2010) drew on the work of Lincoln and Guba (1985) and presents *four* ways to verify qualitative research: *credibility, dependability, transferability and confirmability*. I use these four constructs as organising concepts for the discussion that follows. Under each of these, I incorporate some of the “legitimation methods” suggested by Onwuegbuzie and Leech (2006 pp. 238-246) for assessing the authenticity of a research study.

Credibility refers to the believability of the findings. Qualitative researchers need to offer reassurances that the data has been produced and checked in accord with *good practice* in order to allow judgements to be made about the credibility of the data (Denscombe, 2010). To ensure credibility I have used multiple data sources, my research has entailed prolonged engagement in the field and has been grounded in field work both in research and other after school maths clubs. Additionally, my supervisor reviewed the video recordings of the task-based interviews and verified that the coding I used in the analysis was recognisable.

To demonstrate *dependability*, the researcher needs to provide an explicit account of the methodological procedures undertaken and the decisions that took place during the research process in the form of an “audit trail” (Denscombe, 2010; Onwuegbuzie & Leech, 2006; Rosenberg & Yates, 2007). This enables other researchers to evaluate if these “constitute reputable procedures and reasonable decisions” (Denscombe, 2010 p.300). In this way other researchers can reliably replicate the research. Qualitative research designs are usually flexible, evolving so the audit trail becomes important. This resonated with the design for this particular study.

My audit trail involved comprehensive research journal notes and reflective recordings made during the entire research process about the decisions I took and the challenges and successes I encountered. In this chapter I have included detail of how instruments developed and why, how data collection and how analysis was carried out. Furthermore, I have provided full transcripts of the analysis episodes (see Appendix I) to give the reader opportunities to see if they agree with my analysis.

Drawing on other sources, Onwuegbuzie and Leech (2006) offered a notion they called '*peer debriefing*'. Peer debriefing provides a logical, external evaluation of the research process. The role of the peer debriefer is as the 'devil's advocate', "a person who poses difficult questions about the procedures, meanings, interpretations, and conclusions" (p. 244). Mellony Graven, as the South African Numeracy Chair, my supervisor and fellow club mentor has played this role throughout this study. As I have explained, my study is situated within the work of the SANC project and feeds into the joint work undertaken by the project. It is therefore important that this type of role is carried out if the findings from my study are to be relevant and replicable in the broader project and beyond.

Transferability refers to evidence supporting the generalisation of findings to other contexts - across different participants, groups, situations, etc. The issue of generalisability in qualitative research is a complex one and critics of qualitative research (and the case study design) generally ask how we can generalise on the basis of small samples. Transferability suggests rather that the question is to what extent could the findings be *transferred* to other instances or cases? To achieve this, the researcher needs to supply information enabling others to infer the relevance and applicability of the findings (for example to other people and settings) on which to base a comparison (Denscombe, 2010). The notion of transferability is of importance for this study as the findings inform both the after school club and NICLE teacher development programmes in the SANC project.

To this end, in this and other chapters, I have provided details of the project in which I work, my role in the project, the empirical field of the research and the learners in the two case study clubs. Moreover, by using a multi-site case study approach, I have been able to compare and contrast findings across two clubs. Finally, I have collected and presented rich data and thick descriptions, to enable the reader to make comparisons.

Confirmability refers to the objectivity (neutrality) of the research and the extent that the findings are free from the influence of the researcher who conducted the enquiry. In interpretive, social research, the role of the self in the research is paramount. Therefore the researcher must provide a *reflective* account of the self and how this impacts the research (Denscombe, 2010). Reflectivity is an integral part of this study and is evident specifically in the influence the pilot study had on this research, in the successes and challenges that I encountered during the study and in my role in this study and the wider SANC project. Furthermore, in this chapter I have brought to the fore the particular challenges of working within a Vygotskian perspective specifically with regard to the mediational nature of the research instruments and the social construction of the data and the presentation of the findings.

4.8 CHAPTER FOUR: CLOSING REMARKS

In this chapter I situated my study in a broad interpretive paradigm and examined and reviewed alignment between the theoretical, conceptual, methodological and analytical frameworks of my study. This contribution of my work lays out the relationships and gives clear connections between the frameworks discussed in other chapters of this study for the reader and the broader research communities in which I participate.

I described the design of the research in terms of timescale, data collection methods and approach to analysis. Finally I dealt with various methodological successes, tensions and dilemmas that arose during the study, documented the ethical considerations and discussed ways of ensuring that the study is authentic. Methodological contributions in this chapter include:

- The use of timed fluency activities, along with personal learner reflections on those activities, enabled a complementary research and developmental tool for assessing the changing levels of learners' mathematical proficiency over time. Not only did the activities provide me as a researcher and mentor, with a quick way of tracking, evaluating, encouraging and valuing learner progress but they also provided a mechanism for the learners to practice the fluency they were developing through other activities of the club. More importantly, the use of learner reflections assisted learner buy-in and reduced the stress related to such timed assessments. This alleviated, to some extent, my ethical unease with the use of such instruments.
- The generation of quantifiable data in terms of MP interview scores for the LFIN as a means of presenting results from the MP interviews and allowing comparisons between the two clubs and has allowed me to supplement the qualitative individual LFIN profile data that is inherent in the framework. This could provide a useful and practical contribution to the local research using Wright et al.'s (2006) Maths

Recovery programme which is increasingly being researched for use in groups of learners rather than with individual learners[24].

- The operationalisation of Meira and Lerman's (2001, 2009) attention catching notion and how this links to subsequent mediation is another contribution. Meira and Lerman (2010) link the emergence of a ZPD as dependent on participants catching each other's attention. I provided an analysis framework for this notion as described in this chapter. I have shown how these attention catching mechanisms (ACMs) can be used to examine attention capturing sequences and their relationship with mediating practices, thereby making a connection between how attention is caught and the mediation that takes place as a result. These finding are in presented in Chapter Six.

In the next chapter I present and discuss the findings for research question one which investigates learner mathematical proficiency progress during their participation in the case study clubs.

---- END OF CHAPTER FOUR ----

[24] A number of Masters and PHD students currently studying in the SANC project are investigating the possibilities of using the MR programme with groups of learners.

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CHAPTER 5 LEARNERS' EVOLVING MATHAMATICAL PROFICIENCY - PRESENTATION, ANALYSIS AND DISCUSSION OF FINDINGS

Research question one: How do learners' mathematical proficiency levels evolve (if at all) over the period of participation in the maths club?

5.1 INTRODUCTION AND CHAPTER OUTLINE

Progress (or lack thereof) in mathematical proficiency of the club learners *over time* is the focus of research question one. As explained in Chapter Four, in order to answer this research question, I present data collected in two forms: firstly from the *Mathematical Proficiency (MP) interview*s (adapted from Wright el al, 2006 and Askew et al., 1997) and secondly from the *fluency assessments.* The interviews were administered in March and November of 2012 and the fluency assessments in March and July/August 2012.

In this chapter, I examine the results from each of these instruments for each of my two case study clubs and then provide an overall picture of mathematical proficiency progress across the two clubs in the concluding discussion section. The analysis frameworks used in this chapter are the Learning Framework in Number (LFIN) and indicators for three of the five strands of mathematical proficiency (Kilpatrick et al., 2001) namely conceptual understanding, procedural fluency and adaptive reasoning. It should be noted that there is no intention to specifically attribute any progress in mathematical proficiency to the effect of the clubs. This chapter is structured as follows:

Section 5.2

In this section I present the results and findings from the *MP interview*. For each of the two clubs I specifically present two different views of the data to show learner progress over time: MP interview score data (broad and mostly quantitative) and MP interview learner LFIN profile data which was qualitative. This data provided a profile for each learner based on how they answered questions and an analysis of their progress across aspect levels.

Section 5.3

In this section I present the results and findings from the *fluency assessment* instrument for each club and how scores (specifically in completion and accuracy) shifted over time.

Section 5.4

In this section I share a *narrative vignette* for one club learner in order to illuminate individual learner progress across the two instruments with more depth and richness.

Section 5.5

In this section I summarise and discuss the results across both instruments for both case study clubs and draw together a number of insights that have arisen from this analysis.

Section 5.6

In this final section I reflect on working with the LFIN for analysis purposes and the implications of this for other researchers. Supporting data for this chapter is provided in Appendices G and H.

5.2 FINDINGS OF THE MATHEMATICAL PROFICIENCY INTERVIEWS

Recall from Chapter Four that the LFIN aspects used in this study are:

A - *Structuring numbers 1 to 20*
B - *Number words and numerals*
C - *Conceptual place value*
D - *Early arithmetic strategies*
E - *Early multiplication and division*

Full descriptions of these were provided in Chapter Four. For simplicity in writing and presenting tables and graphs in the sections that follow, I refer to each aspect by its allocated *letter*.

In the presentation of data for each learner in the sections below, additionally I refer to examples where I identified instances of learners exhibiting or not exhibiting qualities of the first three strands of mathematical proficiency i.e. conceptual understanding, procedural fluency and adaptive reasoning. I did this in order to link learner progress to Kilpatrick et al.'s (2001) strands of mathematical proficiency, as this framework of proficiency is a key construct for research question one and for broader work in the SANC project.

In the next sections (5.2.1 and 5.2.2) I review the MP interview results for each club firstly in terms of learner scores and then in terms of the methods used by learners to answer the interview questions. These methods inform how the learner was placed at different levels or stages in each LFIN aspect.

5.2.1 MP INTERVIEW RESULTS: ELMTREE PREP

Overall Club Scores for Elmtree Prep

Table 22 below provides a summary of the results for the seven learners in the Elmtree Prep club in the two MP interview assessments and shows the percentage change from the March to November 2012 assessment.

Table 22: Overall MP interview: % scores for seven learners in Elmtree Prep[25]

Learner	Mar	Nov	% Change
Anathi	88.6%	98.9%	+10.2%
Cebisa	92.0%	95.5%	+3.4%
Kholeka	96.6%	100.0%	+3.4%
Nate	87.5%	94.3%	+6.8%
Zac	92.0%	97.7%	+5.7%
Thembela	80.7%	98.9%	+18.2%
Zintle	88.6%	95.5%	+6.8%
Averages	**89.4%**	**97.2%**	**+7.8%**

The table shows there was overall improvement ranging between 3.4% and 18.2% across the seven learners (with an average improvement of 7.8%). In November, every learner achieved a score of over 94% in the interview. Kholeka achieved 100% in November showing a small improvement since her March scores were already high (96.6%). Thembela made the greatest overall improvement (18.2%) whilst Cebisa and Kholeka showed the least improvement (3.4%). The scores reflect that these seven learners progressed during their participation in the club.

Along with these increases in scores, the interviewers[26] noted that all the learners completed the November interview in 10 to 15 minutes less than in March indicating that learners used quicker or more efficient methods to answer the questions or that they simply 'knew' more number facts. Examining the March and November interview scripts in detail to ascertain the methods they used confirmed both these observations.

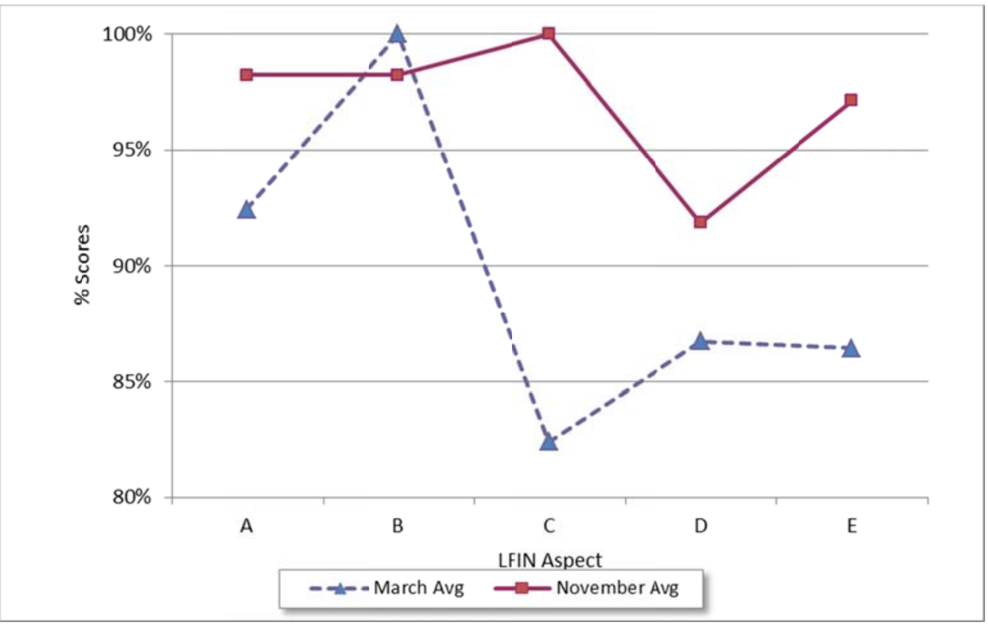
[25] Appendix G shows detailed March and November scores for each LFIN aspect for each learner

[26] Myself and Varonique Sias from the SANC Project.

Overall Elmtree Prep Aspect Summary

The graph in Figure 15 shows overall average progress across the different LFIN aspects for the seven Elmtree Prep club learners.

Figure 15: MP interview: overall average % score per LFIN aspect for Elmtree Prep



LFIN ASPECT KEY:
A: *Structuring Numbers 1 to 20*
B: *Number Words and Numerals*
C: *Conceptual Place Value*
D: *Early Arithmetic Strategies*
E: *Early Multiplication and Division*

The graph shows the most substantial average change was in *conceptual place value* (aspect C), followed by *early multiplication and division* (aspect E).

Following the March assessment, I decided to focus on activities that developed *conceptual place value* (aspect C) and *early arithmetic strategies* (aspect D) in this club. Using observations from the early club sessions for Aspect C, I noted that the club learners were relatively strong in their understanding of place value with respect to units, tens and hundreds. As a result I decided to work on strengthening their conceptual place value through mental activities and games by practicing incrementing and decrementing on and off the decuple (a multiple of ten) and incrementing and decrementing through 100, 200, 1000 etc. For Aspect D I focussed on mental facility and development of strategies for working with numbers to 100 (and over) that did not rely on using the standard vertical algorithms for addition and subtraction. In the second half of the year, I focused on developing the club learners multiplicative thinking (Aspect E) using a variety of array based activities as well as developing their logical thinking skills through an assortment of logic games and puzzles. This focus could account for the changes in Aspect C and E.

Table 23 below shows the percentage change that individual learners in this club achieved between the March and November assessments for each LFIN aspect.

Table 23: Learner MP interview % change March to November per LFIN aspect for Elmtree Prep

Learner	A	B	C	D	E
Anathi	0%	9%	23%	7%	10%
Cebisa	0%	6%	15%	-14%	5%
Kholeka	0%	0%	8%	0%	10%
Nate	-13%	6%	15%	-7%	20%
Zac	0%	3%	8%	14%	5%
Thembela	0%	19%	23%	21%	15%
Zintle	0%	-3%	31%	14%	10%
Averages	**-2%**	**6%**	**18%**	**5%**	**11%**

LFIN ASPECT KEY:
A: *Structuring Numbers 1 to 20*
B: *Number Words and Numerals*
C: *Conceptual Place Value*
D: *Early Arithmetic Strategies*
E: *Early Multiplication and Division*

Particularly notable changes (i.e. over 15 percentage points) shown in the table include: Thembela achieved the highest change (19 percentage points) for Aspect B, Zintle the highest for Aspect C (31 percentage points), Thembela for Aspect D (21 percentage points) and Nate for Aspect E (20 percentage points). Aspect A, where the learners were already strong shows a negative progression for Nate, which resulted from a slip in Task 16 of the interview. Kholeka, who was strong in March, maintained her level, with two areas of progress in Aspects C and E. Thembela progressed well in all aspects. For Aspect D, Nate and Cebisa both show negative change. Possible reasons for these overall changes are discussed in more detail later in this section.

Although I am not an advocate of teachers ranking learners from assessments, in this case using the overall percentage scores from the interviews to rank the learners from highest to lowest score provided some insight into differential learner progress over time. Learner rank positions (provided in Table 40 in Appendix G) show that Kholeka answered the most questions correctly in both the March and November interviews, placing her in 1st position. Of more interest are the changed positions of the other learners following the November interview. Notably Thembela made a substantial jump from 5th position to joint 2nd position as a result of her consistent improvement of 15 percentage points or greater across LFIN aspects B to E (she had already achieved 100% for Aspect A in the March interview).

Individual learner LFIN profiles: Introduction

In the next section I report on findings that focus on the LFIN profile for each club learner. The scores presented in the above tables above gave me a broad view of where learners were and the progress they made over time. These percentage scores and aggregations did not show the more in-depth and nuanced story of how learners arrived at their answer, or how efficient or sophisticated their chosen method of working it out was. The LFIN profile provided this information and is the primary purpose of the MP interview. This data was derived from notes made on learner scripts during the interviews.

These conventions are used in the individual learner LFIN tables that follow in the section below and in Appendix H. The MP interview script is included in Appendix B.

Table 24: Conventions used in the individual learner LFIN tables

Convention	Example
A letter followed by a number in square brackets indicates the LFIN aspect and the highest level or stage for that aspect.	A [6] For example, the highest level in Aspect A is 6[27].
Two numbers separated by a slash, indicate that the learner’s position falls between two LFIN levels (i.e. a borderline position).	2/3 For example, shows placement of the learner at level 2, borderline level 3.
➔ indicates movement from one LFIN level to another over time (i.e. from March to November) for the learner.	3➔4 For example, indicates the learner moved from level 3 to 4 over time

The levels of the LFIN describe mathematical progression in order of increasing sophistication from inefficient count-by-ones strategies and rote procedures to more flexible, efficient computation and stronger numerical reasoning (Wright, Martland, Stafford, et al., 2006). In this section I analyse each learner’s progress and present a table that shows changes in LFIN levels across club learners. Using the table as the basis for

[27] Note: although this aspect has 6 levels, the MP interview only asked questions up to level 4.

discussion, I review the methods and strategies each learner used to answer questions from the MP interviews and indicate how and why the learner has been placed at certain levels on the LFIN framework as a result. Tables showing all learners' results are shown in Appendix H. It is important to note that the progress shown in this section may or may not correlate with progress made in terms of the scores shown in the previous section. This is because progress in LFIN levels reveals increased sophistication in methods used or increased fluency not accuracy. Additionally I note where learners may or may not have exhibited qualities of conceptual understanding, procedural fluency and adaptive reasoning.

MP interview results: LFIN profiles for individual Elmtree Prep learners

Anathi

	A [6][28]	**B (i) [4]**	**B (ii) [5]**	**B (iii) [5]**	**C [6]**	**D [5]**	**E [5]**
Mar - Nov LFIN Level Change	4➔4	3➔4	5➔5	4➔4	2➔3	2/3➔2/3	1/2➔4/5
ASPECT KEY: **A** - *Structuring Numbers 1 to 20* **B** - *Number Words and Numerals*				**C** - *Conceptual Place Value* **D** – *Early arithmetic strategies* **E** - *Early Multiplication and Division*			

Anathi showed progress in her LFIN levels for **Aspects B (i), C and E**. By correctly identifying 1025, ½ and ¼ and then the number line positions in the November interview, Anathi moved from level 3 to 4 in **Aspect B (i).**

For **Aspect C**, in March, when adding or subtracting 10 from a given number (*Task 10)*, she answered 3 of the 4 questions incorrectly. In *Task 9* although she did not recount each 10-dot strip that was laid down, she added 10 to the previous total each time a new dot strip was shown. Thus I placed her at level 2 for Aspect C. In November, all questions in Task *10* were answered correctly and quickly. For *Task 9* she answered instantaneously when a *set* of strips were laid down. When asked how she did *Task 9* so quickly, she said "10 x 4" and "10 x 7" (indicating she was using known multiplication facts to solve the problem). This demonstrated that she could verbalise her thinking (*adaptive reasoning*) and showed flexibility and efficiency *in procedural fluency*.

[28] Note: although this aspect has 6 levels, the MP interview only asked questions up to level 4. Therefore in the analysis, the highest level for the learners will be four.

In **Aspect E**, her March interview showed that she shared counters in ones when doing partition division (*Tasks 21 and 22*). She was unable to find ¼ of the marbles in *Task 24*. She counted in 3s and knew the 5 x 3 array was the same when turned around (*Task 17)*. Based on these responses I positioned her at level 1 to borderline 2. In November, she used known multiplication and division facts such as 15 ÷ 3 and 3 x 4, so I placed her at level 4, borderline 5. This represents a jump of 2 levels or more and shows increased efficiency in *procedural fluency*. In terms of *adaptive reasoning* she did not feel that she had to use the counters to answer a question if she knew the answer without them. She thus knew when to use a particular method to solve the problem.

Cebisa

	A [6]	B (i) [4]	B (ii) [5]	B (iii) [5]	C [6]	D [5]	E [5]
Mar – Nov LFIN Level Change	4➔4	3➔4	4/5➔5	4➔4	2/3➔2/3	4➔4	2/3➔3/4
ASPECT KEY: **A** - *Structuring Numbers 1 to 20* **B** - *Number Words and Numerals*				**C** - *Conceptual Place Value* **D** - *Early arithmetic strategies* **E** - *Early Multiplication and Division*			

Cebisa's results showed that she made progress in aspects B (i and ii) and E between the March and November interviews. Because she used the same strategies to answer the questions in November that she did in March, she did not make progress in LFIN levels for **Aspects A, B(iii), C and D**. For example, she did not exhibit elements of *adaptive reasoning* in her responses to *Task 12 (a & b*) and *Task 15*. She simply re-calculated the answer each time using her initial strategy rather than seeing a pattern in the presented problems. In November, she generally approached these problems in the same way, although in *Task 15*, there was evidence of her beginning to see patterns and relationships between the questions.

In March for **Aspect B (i)** she stated that '1025' was hard (*Task 1*) and failed to identify it along with one of the number line questions (*Task 2*). I thus placed her at level 3. In her November interview, Cebisa correctly identified 1025 and the number line positions showing progress in Aspect B (i) to level 4, and showing progression in *procedural fluency*.

In March for **Aspect B (ii)** although she self-corrected, she showed some difficulty when counting forward from 93 to 112 when she reached 110 thus revealing a lack of *procedural fluency*. This was not evident in November, thus she moved to level 5.

For **Aspect E** in March, Cebisa responded to *Tasks 17 to 24* by sharing counters in different ways: sometimes she counted in ones and sometimes in multiples of 3, 5 or 10 depending on the task. She recounted the 5 x 3 array when it was turned around in *Task 17* rather than recognising it as the same amount of dots revealing an absence of *conceptual understanding* in the relationship between the two arrays. As a result I placed her at a level 2 borderline 3. In November, she shared items in multiples, but still used the counters for *Task 22* indicating a reliance on concrete tools for solving multiplication and division problems. However, for *Task 21*, she used the known fact of 5 x 3. Based on these responses I placed her at level 3, borderline 4. She showed a developing *fluency* with known multiplication facts.

Kholeka

	A [6]	**B (i) [4]**	**B (ii) [5]**	**B (iii) [5]**	**C [6]**	**D [5]**	**E [5]**
Mar – Nov LFIN Level Change	4➔4	4➔4	5➔5	4➔4	3➔3	4➔4/5	2/3➔4/5

ASPECT KEY: **A** - *Structuring Numbers 1 to 20* **B** - *Number Words and Numerals*	**C** - *Conceptual Place Value* **D** - *Early arithmetic strategies* **E** - *Early Multiplication and Division*

Kholeka progressed in two aspects: **D and E** in LFIN levels. Looking at **Aspect D**, in March she re-calculated question 16+9 rather than using the previous question of 16+10 as a guide and had a very muddled approach to solving 43-15. I placed her at level 4 as she did show some strategy use for the addition sums in *Task 15*.

<u>Question 12d:</u> 43 - 15 =
Her strategy: 43-10=33; 33-3=30; 30-2=28

<u>Question 13a:</u> 12 people are on a bus and 5 get off. How many people are on the bus now?
Her strategy: Double 6 is 12. 5 is one less, so answer must be 1 more = 7

Figure 16: Kholeka's strategies used in tasks 12d and 13a in November interview

Figure 16 shows her November strategies for parts of *Tasks 12 and 13*. She used 16+10 to answer 16+9 and her explanation and strategy for solving *43-15* was more coherent, revealing that she could explain her thinking. This shows some *adaptive reasoning*. She was also able to come up with an alternative way of solving this when asked. This indicates some *conceptual understanding,* as one indicator for this is that a learner can represent problems using multiple representations. She used a doubling strategy to arrive at the answer for *Task 13a* as shown in the figure above. In *Task 15* she saw the patterns in the first questions (i.e. 9+3 and 7-5) and used these to work out the answers for the subsequent ones. I would suggest that Kholeka used these patterns to solve the subsequent problems, thus she began to develop some elements of *adaptive reasoning*.

For **Aspect E** in March, she used counters for the partition division questions, although she did most of her counting and subitising in multiples rather than in ones. She could not find **¼** of the marbles. In her November interview, she used known facts of 3 x 5; 3 x 8 and 6 x 4 rather than using the counters for the partition division questions, and she was able to answer the ¼ of the marbles question correctly. She thus moved from a level 2 borderline 3 to a 4 borderline 5. By using known facts, she showed efficiency in *procedural fluency*. In terms of *adaptive reasoning*, she knew when to use a particular method to solve a problem and did not use the counters even though they were available.

Nate

	A [6]	**B (i) [4]**	**B (ii) [5]**	**B (iii) [5]**	**C [6]**	**D [5]**	**E [5]**
Mar – Nov LFIN Level Change	4➔4	3➔3	4➔5	4➔4	2/3➔3	4➔4	2➔3/4
ASPECT KEY: **A** - *Structuring Numbers 1 to 20* **B** - *Number Words and Numerals*				**C** - *Conceptual Place Value* **D** - *Early arithmetic strategies* **E** - *Early Multiplication and Division*			

In terms of LFIN levels, Nate made progress in three **Aspects: B (ii), C and E**. For **Aspect B** (ii) in March, he skipped 101 in the 93 to 112 FNW sequence which he did not do in November. For **Aspect C**, he used the same strategy for working with the 10-dot strips (*Task 9)* in both interviews showing *conceptual understanding* of sets of tens, but struggled to *take 10 away from 70* and *100 away from 634* in March. In his November interview, he answered all the +/- 10 and 100 questions correctly and worked them out mentally, thus I placed him at level 3. With his November interview responses he demonstrated flexibility, accuracy and efficiency in *procedural fluency*.

In the March interview for **Aspect E**, he shared counters in ones and answered both the ½ and ¼ marbles question (*Task 24)* incorrectly (simply saying "2" and "4") revealing an absence of *conceptual understanding* of what ½ and ¼ meant. In November, he did not instantly know the answers for the ½ and ¼ but he worked them out by dividing the 8 marbles by 2 to get 4 (half) and then dividing the 4 by 2 to get a quarter. This showed *fluency* in working with dividing by 2 and developing *conceptual understanding* and *adaptive reasoning* in what these fractions meant and the relationship between them.

After the November interview, I placed him at level 3 borderline 4 as he had used some known multiplication facts (e.g. 5 x 3). I did not put him at level 4 because he could not recall the 24 ÷ 3 or 24 ÷ 4 facts for *Task 22* and he moved the counters around a bit before finding an answer to this task. It seemed that the counters restricted his thinking but because he could not recall the facts as he wished, he became flustered. This perhaps reveals a lack of *conceptual understanding* and *procedural fluency* in recalling known multiplication facts and an understanding of what partition division is.

Zac

	A [6]	**B (i) [4]**	**B (ii) [5]**	**B (iii) [5]**	**C [6]**	**D [5]**	**E [5]**
Mar – Nov LFIN Level Change	4➔4	4➔4	5➔5	4➔4	3➔3	4/5➔4/5	1/2➔4/5
ASPECT KEY: **A** - *Structuring Numbers 1 to 20* **B** - *Number Words and Numerals*				**C** - *Conceptual Place Value* **D** - *Early arithmetic strategies* **E** - *Early Multiplication and Division*			

Zac maintained his March LFIN levels in the November interview in all but one aspect. He made sizeable progress in **Aspect E** from March to November, moving 3 LFIN levels or more, indicating a progression from more concrete methods to using known facts and multiplication concepts. In March, his approach to partition division with redistribution (*Task 22)* was muddled and he answered the ¼ of the marbles question (*Task 24*) incorrectly. In *Task 17*, he worked out the number of dots in the 5 x 3 array using "6+6=12; 12+3=15". I thus placed him at level 1 borderline 2.

In November he still could not find ¼ of the marbles but used a combination of known multiplication facts (e.g. 5 x 3) and strategies to answer the other questions rather than using counters. For example, he did not know the 24 ÷ 3 fact for *Task 22* but he answered 8 and explained that he used: "8 + 8 = 16; 16 + 8 = 24" to arrive at his answer. Based on these responses, I placed him at level 4 borderline 5. His response exhibits *procedural fluency* (flexibility), *conceptual understanding* of the relationship between repeated addition (one form of multiplication) and division and *adaptive reasoning* in being able to explain how he arrived at his answer.

Thembela

	A [6]	B (i) [4]	B (ii) [5]	B (iii) [5]	C [6]	D [5]	E [5]
Mar – Nov LFIN Level Change	4➔4	3➔4	3➔5	4➔4	2➔3	2/3➔3	1/2➔1/2
ASPECT KEY: **A** - *Structuring Numbers 1 to 20* **B** - *Number Words and Numerals*				**C** - *Conceptual Place Value* **D** - *Early arithmetic strategies* **E** - *Early Multiplication and Division*			

Thembela progressed in four **Aspects: B (i and ii), C and D** in terms of LFIN levels. With the exception of level B (ii), she moved only one level for each aspect on the LFIN, indicating that although her methods were becoming more sophisticated, she still had room to progress further.

In her March interview for **Aspects B (i and ii)** she was unable to identify 1025, ½ and number line positions and she said "10 hundred" for 100 in the forward number sequence 93 to 112, thus I placed her at level 3 for the two B aspects. She answered these all correctly in her November interview, thus she progressed to levels 4 and 5 respectively. Her ability to answer the number line task in the November interview exhibits both *conceptual understanding* and thinking logically about the relationships between numbers and concepts and shows some *adaptive reasoning.*

For **Aspect C** in her first interview, she added 10 each time a 10-dot strip was laid down (*Task 9*) and she struggled with *add 10 to 294*, *take 10 away from 700* and *add 100 to 932*. Thus I placed her at level 2. In her November interview, she got these all correct and worked them out mentally, showing efficiency in *procedural fluency* and progression in LFIN levels. For *Task 9*, she did the same as her first interview except for the final question where she verbalised her final answer as 7 x 10 + 4. By using a known fact, she showed some progress in *procedural fluency* as well. This moved her to level three for this aspect.

For **Aspect D**, her progress was slight (from level 2 borderline 3 to 3) because she saw the patterns in *Task 15* and used them to solve the questions in November. Otherwise, she used the same strategies that she did in the first interview. Her ability to see the patterns shows she was developing *conceptual understanding* and by verbalising her thinking, she was beginning to *reason adaptively*.

Zintle

	A [6]	B (i) [4]	B (ii) [5]	B (iii) [5]	C [6]	D [5]	E [5]
LFIN Level Change	4➔4	4➔4	5➔5	4➔4	2➔2/3	2/3 to 2/3	1/2➔2/3

ASPECT KEY: **A** - *Structuring Numbers 1 to 20* **B** - *Number Words and Numerals*	**C** - *Conceptual Place Value* **D** - *Early arithmetic strategies* **E** - *Early Multiplication and Division*

Zintle made progress in **Aspects C** and **E** on the LFIN profile. For **Aspect C**, her progress was mostly in her skill / demonstration of mentally working out the answers for +/- 10 and 100 (*Tasks 10 and 11)* and answering them correctly in the November interview, which she was unable to do in March. This moved her from a 2 to a borderline 3 and demonstrated accuracy and efficiency in *procedural fluency*.

Her progress in **Aspect E** was a little more marked with a move from level 1 borderline 2 to level 2 borderline 3. In March she recounted the 5 x 3 array when it was turned (*Task 17*), had a muddled approach to sharing counters in *Task 21* and was unable to work out the ¼ of the marbles question in *Task 24*. In her second interview, she knew the 5 x 3 array was the same regardless of which way it was turned. She did not share counters; rather she used repeated addition to solve *Task 22* (e.g. she counted 3, 6, 9 up to 24 and 4, 8, 12 up to 24) indicating *conceptual understanding* of the problem and she displayed a more efficient way of approaching the sharing task than relying on concrete methods. She was also able to say what a ¼ of the marbles were in *Task 24*.

This concludes the presentation of the MP interview results for Elmtree Prep. In the next section I present the MP Interview results for Luhlaza Primary.

5.2.2 MP INTERVIEW RESULTS: LUHLAZA PRIMARY

Overall club scores for Luhlaza Primary

As discussed in Chapter Four, I was only able to conduct MP interviews for four of the ten learners in November, as the learners were not at school at the end of term. Thus I report on the results for these four learners: Aphiwe, Akhona, Chebe and Kuhle. Table 25 shows the percentage change that each learner achieved between the March and November assessments for each LFIN aspect in the Luhlaza Primary club.

Table 25: Overall MP interview: % scores for four learners at Luhlaza Primary[29]

Learner	Mar	Nov	% Change
Aphiwe	85.2%	89.8%	+4.5%
Akhona	80.7%	95.5%	+14.8%
Chebe	81.8%	92.0%	+10.2%
Kuhle	94.3%	98.9%	+4.5%
Averages	**85.5%**	**94.0%**	**+8.5%**

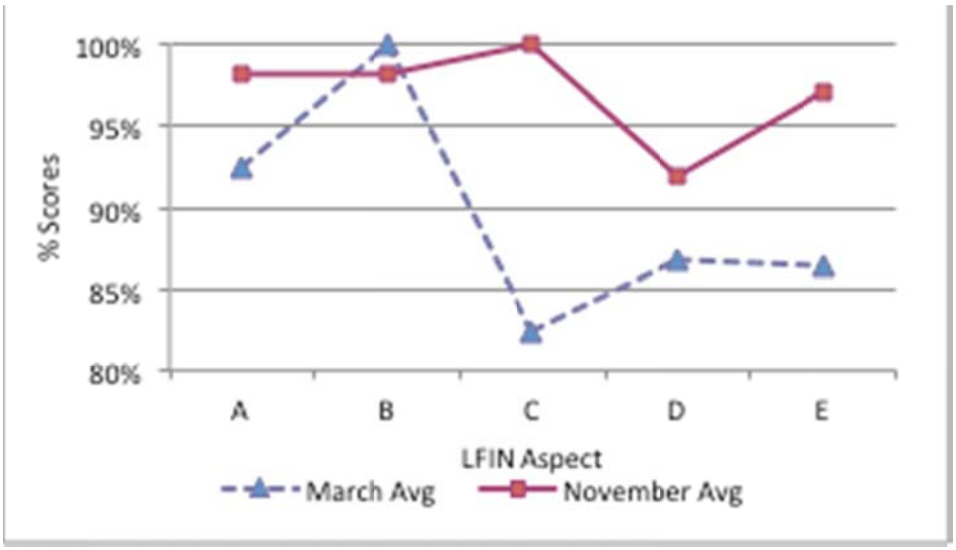
There is an improvement across the four learners ranging from 4.5% to 14.8% (an average of 8.5 percentage points) from March to November. In November, each learner achieved a score of nearly 90% or more, whilst in March, Kuhle was the only learner to achieve a percentage score in the nineties. Akhona made the biggest overall improvement with 14.8 percentage points whilst Aphiwe and Kuhle had smaller improvements of 4.5 percentage points. For Kuhle this small improvement was somewhat due to her March results being relatively high (94.3%).

[29] Detailed scores for each aspect for each learner are available in Appendix G.

Overall Luhlaza Primary Aspect Summary for each LFIN aspect

The graph in Figure 17 shows overall progress for these four learners in Luhlaza Primary for the different LFIN aspects. The most substantial changes were in *conceptual place value* and *early multiplication and division* (aspects C and E) with smaller changes in *structuring numbers 1 to 20* and *early arithmetic strategies* (aspects A and D).

Figure 17: Average MP interview: overall % score per Aspect for four learners at Luhlaza Primary[30]



LFIN ASPECT KEY:
A: *Structuring Numbers 1 to 20*
B: *Number Words and Numerals*
C: *Conceptual Place Value*
D: *Early Arithmetic Strategies*
E: *Early Multiplication and Division*

Following the initial assessment in March, I decided to focus on strengthening *conceptual place* value (aspect C) in this club. We worked with Flard Cards (also know as arrow cards) for developing understanding of 3 and 4-digit numbers (aspect B) and for building conceptual place value (aspect C). We also did some work with adding and subtracting numbers using Flard cards by decomposing the numbers which took us into strategies for adding and subtracting numbers to 100 and over (aspect D). Later in the year, I continued work on aspect D by introducing activities that allowed learners to work mentally with strategies for solving number problems. Although I did not have time to focus on early multiplication and division (aspect E), I started each session with mental activities designed to strengthen number combinations to 10 and 20, adding and subtracting 10 and 100 (aspect B and C) and skip counting in multiples such as twos, threes and fives. These foci could account for some of the progress in aspects C, D and E.

Table 26 below shows the percentage change for the four individual learners interviewed achieved between the March and November assessments for each LFIN aspect.

Table 26: Learner MP interview % change March to November per LFIN aspect for four learners at Luhlaza Primary

Learner	A	B	C	D	E
Aphiwe	13%	3%	23%	-21%	10%
Akhona	13%	19%	23%	14%	5%
Chebe	0%	6%	15%	0%	20%
Kuhle	0%	0%	8%	14%	5%
Averages	**6%**	**7%**	**17%**	**2%**	**10%**

LFIN ASPECT KEY:
A: *Structuring Numbers 1 to 20*
B: *Number Words and Numerals*
C: *Conceptual Place Value*
D: *Early Arithmetic Strategies*
E: *Early Multiplication and Division*

The four learners interviewed showed positive progress over time in all aspects except Aphiwe who showed regression for Aspect D which -21 percentage points. Particularly notable changes (i.e. over 15 percentage points) shown in the table include: Aphiwe and Akhona joint highest for Aspects A and C (13 and 23 percentage points respectively), Akhona achieved the highest change (19 percentage points) for Aspect B, Akhona and Kuhle for Aspect D (14 percentage points) and Chebe for Aspect E (20 percentage points). Kuhle, who was strong in March for Aspects A and B maintained her level, with three areas of progress in Aspects C, D and E. Of note is that she achieved 100% in all aspects except E in the November interview. Possible reasons for these overall changes are discussed in more detail later in this section.

MP interview results: LFIN profiles for individual Luhlaza Primary learners

In this section I report on the findings that focus on the LFIN profile for each of the four club learners for whom I collected data. I use the same conventions as used in representing the data for Elmtree Prep. I take each learner in turn and present a table that shows changes in LFIN levels and compares this against their aspect score as discussed in the previous section. Using the table as the basis for discussion, I review the methods and strategies each learner used to answer questions from the MP interview and indicate how the learner has been placed at certain levels on the LFIN framework and comment on progress in conceptual understanding, procedural fluency and adaptive reasoning. It is important to note that the progress shown in this section may or may not correlate with progress made in terms of the scores shown in the previous section. This is because progress in LFIN levels reveals increased sophistication in methods used or increased fluency not accuracy. Please refer to the MP Interview script in Appendix B if necessary.

Khule

	A [6]	**B (i) [4]**	**B (ii) [5]**	**B (iii) [5]**	**C [6]**	**D [5]**	**E [5]**
Mar – Nov LFIN Level Change	4➔4	4➔4	4➔5	4➔4	3➔3	2➔4/5	2/3➔2/3

ASPECT KEY: **A** - *Structuring Numbers 1 to 20* **B** - *Number Words and Numerals*	**C** - *Conceptual Place Value* **D** - *Early arithmetic strategies* **E** - *Early Multiplication and Division*

Khule made progress in LFIN levels for **Aspect B (ii)** and **D**. For **Aspect B (ii)** a note on her March script indicated that she fumbled a little with forward number sequences although she self-corrected which lead me to place her at level 4. In November, this fumbling was not evident and she completed the sequences fluently. Her confident counting in November moved her into level 5. For Aspect C her strategies for answering the questions in this aspect were the same over both interviews.

Her progress in **Aspect D** is noteworthy. I look at the 43-15= question in *Task 12* first. In March, she answered this incorrectly, making the common mistake of taking the smaller number away from the bigger one in the units thus: $40 - 10 = 30$; $5 - 3 = 2$; 32 which showed a lack of *conceptual understanding* and perhaps indicated following some learned rule. In November, she used a different strategy of working with friendly numbers and breaking numbers into parts (such as 5 into 3 and 2): $43 - 10 = 33$; $33 - 3 = 30$; $30 - 2 = 28$ which shows more understanding. This reveals a level of *conceptual understanding* as she seemed to understand how numbers are made up and *adaptive reasoning* because she knew not to use a set procedure and was flexible in her selected methods.

For the Number Stories (*Task 13*) in March she drew circles on paper to solve the first two questions and she answered the third question incorrectly. In November, she answered all questions correctly and used different strategies. For example, for question one, she worked out the answer by breaking the 5 into 2, 2 and 1 and subtracting these parts from the 12 as follows: $12 - 2 = 10$; $10 - 2 = 8$; $8 - 1 = 7$ revealing a more flexible understanding of numbers and of a whole / part relationship (*conceptual understanding and procedural fluency*). An analysis of her methods enabled me to situate her initially at level 2 for **Aspect D**, whilst her increasingly more sophisticated strategies in November moved her to level 4 borderline 5.

Akhona

	A [6]	**B (i) [4]**	**B (ii) [5]**	**B (iii) [5]**	**C [6]**	**D [5]**	**E [5]**
LFIN Level Change	3/4➔4	3➔4	3/4➔5	4➔4	2➔3	3➔4	2➔2
ASPECT KEY: **A** - *Structuring Numbers 1 to 20* **B** - *Number Words and Numerals*				**C** - *Conceptual Place Value* **D** - *Early arithmetic strategies* **E** - *Early Multiplication and Division*			

Akhona made progress in all aspects except aspect E, moving one level or more in aspects. For **Aspect A**, Akhona moved from a level 3 borderline 4 to a 4 in the November interview. In March she struggled with what was required for *Task 16* questions due to language issues (some rephrasing and visual representation were necessary) and incorrectly answered one question. In November all questions were answered correctly. Recall that although Aspect A in the LFIN has six levels, the MP interview only asked questions up to level 4. Thus the highest level shown in this analysis will be 4.

For **Aspect B (i)** in March, she was unable to identify 1025 and the fractions of ½ and ¼ or to position numbers on a number line. I thus placed her at level 3. In November, she was able to do so, so she moved to level 4 for this aspect.

For **Aspect C**, in March, she was reliant on using her fingers and 'counting on' to try and find answers to +/- 10 and 100 (*Tasks 10 and 11)* whilst in November she answered the questions mentally, perhaps indicating a facility or fluency in working with decuples (*procedural fluency*). This moved her from level 2 to 3. Her strategies for answering the 10 dot strips in *Task 9* were the same for both the March and November interviews, hence having no effect on her progress.

Her progress from level 3 to 4 in **Aspect D** was evidenced by her seeing and reasoning based on the patterns in *Tasks 12a, 12b and 15* and using these patterns to solve the problems rather than recalculating each time, which she did in March. By seeing and using the patterns, she displayed some *adaptive reasoning*. For the number stories (*Task 13)* in March she used marks on paper to solve these (incorrectly) whilst in November she answered them mentally. She still did not arrive at the correct answer, however.

Aphiwe

	A [6]	**B (i) [4]**	**B (ii) [5]**	**B (iii) [5]**	**C [6]**	**D [5]**	**E [5]**
LFIN Level Change	3/4➔4	4➔4	4/5➔4/5	4➔4	1➔2	1➔2/3	0/1➔2/3
ASPECT KEY: **A** - *Structuring Numbers 1 to 20* **B** - *Number Words and Numerals*				**C** - *Conceptual Place Value* **D** - *Early arithmetic strategies* **E** - *Early Multiplication and Division*			

Aphiwe's LFIN profile shows that she moved one level or more in four aspects (**A, C, D and E**). For **Aspect A**, Aphiwe moved from a level 3 borderline 4 to a 4 after the November interview. In March she incorrectly answered one question in *Task 16* but in November all questions were answered correctly.

For **Aspect C** in March, although arriving at the correct answers, she recounted the dots in the 10-dot strips (*Task 9*) each time and used a combination of counting on fingers, working on paper and mental strategies to work out the answers for +/- 10 and 100 (*Tasks 10 and 11)*. She correctly answered 5 of the 8 questions in these tasks. I thus placed her at level 1. In November she counted the 10-dot strips in 10s and then added the four (e.g. 10, 20, 30, 40 + 4) and mentally worked out the answers to *Tasks 10 and 11*. She still did not get all the questions correct however. I thus moved her to level 2.

For **Aspect D** in March, she correctly answered all but one of the questions in *Tasks 12 to 15* by using her fingers or by writing horizontal sums on paper. In November, she incorrectly answered all the questions in *Tasks 13 and 14*, as her script shows that she tried to answer these questions mentally[31]. Therefore, she had moved on from using inefficient finger and paper strategies, to trying to solve these mentally. This shows perhaps that she is developing some flexibility and efficiency if not accuracy in *procedural fluency*. Although

[31] Unfortunately her script doesn't specify what strategies she was using.

she was not successful at this, she showed evidence of trying to use strategies that were more efficient if not sophisticated. In November for *Task 12*, when asked, she revealed her strategies for answering as using decomposition of the tens and ones. For *Task 15*, she used the pattern from the previous sum and added one each time rather than recalculating the sum each time as she did in March. Hence, she moved from level 1 to 2 or borderline 3. Her ability to explain her thinking and to reason based on observed patterns showed development of some level of *adaptive reasoning*.

Aphiwe used counting in ones strategies for most of the **Aspect E** tasks in March. She also recounted the 5 x 3 array when it was turned around and she used counters to correctly answer 3 x 3 and 4 x 5. She was unable to give correct answers for 10 x 4 and 10 x 70. Her answers to the half and quarter of the marbles made little sense (i.e. she answered 7 ½ and 7 ¼ for these). This combination of responses revealed that she was unable to see the group as composite units and I thus placed her at level 0 borderline 1. She was reliant on using concrete methods to answer most of the early multiplication and division questions. This also indicated a lack of *conceptual understanding* of these operations and lack of *efficiency* and *fluency* in working out answers. In November however, she still recounted the 5 x 3 array but she shared counters and counted in multiples rather than ones. Additionally, she gave rapid, correct answers for the half and quarter of the marbles and gave instant answers for some of the multiplication facts such as 3 x 3 and 4 x 5. As she was able to use repeated addition and see composite units, I placed her at level 2 borderline 3.

Chebe

	A [6]	**B (i) [4]**	**B (ii) [5]**	**B (iii) [5]**	**C [6]**	**D [5]**	**E [5]**
LFIN Level Change	4➔4	4➔4	4/5➔4/5	4➔4	1/2➔2/3	5➔5	3➔4
ASPECT KEY: **A** - *Structuring Numbers 1 to 20* **B** - *Number Words and Numerals*				**C** - *Conceptual Place Value* **D** - *Early arithmetic strategies* **E** - *Early Multiplication and Division*			

Chebe's progress is shown in **Aspects C and E**. His progress in **Aspect C** is noteworthy, moving from level 1 to 2 borderline 3. For the 10-dot strips (*Task 9)* in March, he relied on touching each 10-dot strip and counted the dots each time from the beginning when they were laid down. In November, he needed to check this in the first four questions, and then he said "there are many" and in the final question he confidently counted each strip in 10s.

For +/- 10 and 100 (*Tasks 10 and 11)* in March he answered 5 out of 8 questions correctly, stating that he did not “know” the answers to some of the questions. In November, he answered each question correctly, quickly and mentally thus revealing progress in this LFIN aspect and efficiency and accuracy in *procedural fluency*.

For **Aspect E** he moved from level 3 to 4. In March, he recounted the 5 x 3 array when it was turned around (*Task 17)*. In November, he said, “it's the same” and gave an instant answer, demonstrating *conceptual understanding* and that he was able to coordinate the composite units in an abstract way. For *Tasks 21 and 22* in March, he showed no logical method for sharing the counters and counted in ones. In November, he used known multiplication facts of 5 x 3 and 6 x 4 to answer the questions and it was observed that the counters restrained him when he used these to answer a question. It is noteworthy that he demonstrated *procedural fluency* in being able to use the correct known facts for the context but not *conceptual understanding* of being able to represent the problem with counters. It is for this reason that I did not position him in level 5.

5.2.3 MP INTERVIEW RESULTS: SUMMARY ACROSS BOTH CLUBS

The data presented in previous sections suggests that the learners assessed in both clubs made progress to varying degrees as evidenced by the Mathematical Proficiency interview results. Figure 18 below shows the overall club percentage change figures for each LFIN aspect for both case study clubs. Note that there is a limitation in that the curve for Luhlaza Primary only represents four of the ten club learners and is not representative of the whole club.

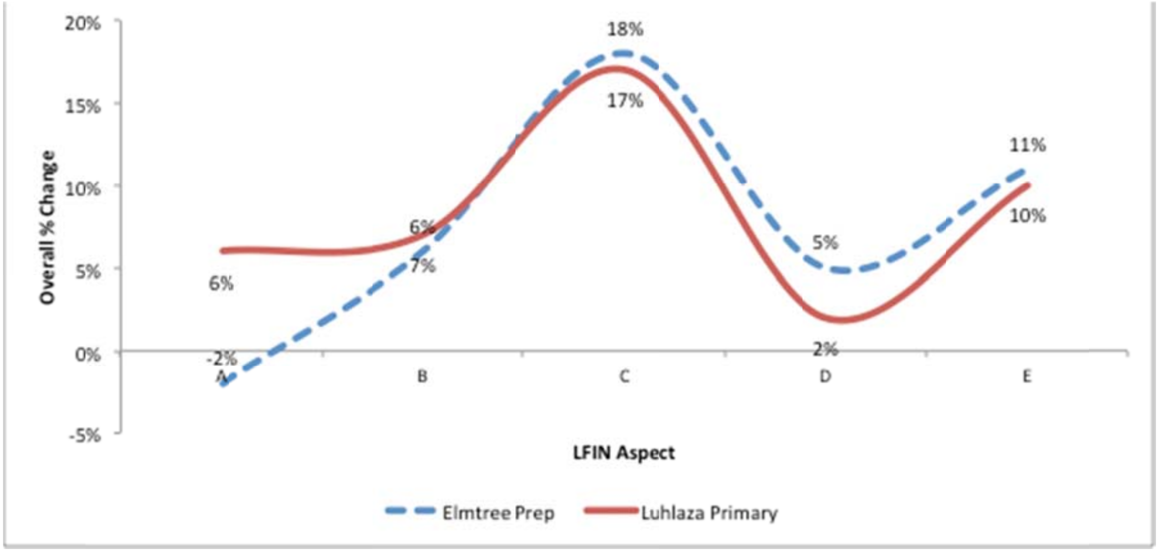


Figure 18: MP interviews: Club comparison - overall % change for each LFIN aspect

Of interest is the similarity in improvements across the two clubs. My focus on Aspect C most likely explains the similar spike in improvement in *conceptual place value* across both clubs. Nate's (Elmtree Prep) error discussed earlier had a negative effect on Elmtree Prep's overall % change for Aspect A. From the data presented here and earlier for individual learners, I would argue that many of the learners showed characteristics of mathematical proficiency across the three strands of conceptual understanding, procedural fluency and adaptive reasoning. In the November interview, learners were not solely relying on using written procedures or rote memorisation to find answers, but were using some combined elements of conceptual understanding, adaptive reasoning and procedural fluency and as such I suggest that they showed some progress in developing mathematical proficiency. I now turn to review the findings for the fluency assessments.

5.3 FINDINGS OF THE FLUENCY ASSESSMENTS

5.3.1 INTRODUCTION

In the Methodology chapter, I described the different timed fluency assessments used for this study and the rationale for using them. The tests included: *add and subtract to 10; doubling; halving; add and subtract 10; add and subtract 100*. In this section I review the results for four of these five as the *add / subtract to ten* were not administered to all learners in all clubs due to absenteeism at the required times. I present the results in terms of changes over time in scores with a specific focus on *completion* and *accuracy* scores although a *traditional* test score is also shown for each learner.

In Chapter Four, I spoke of the ethical dilemma of using these timed activities. My decision to include these as positive learning opportunities in the context of my maths clubs relied largely on developing the necessary club ethos in which to use them and ensuring that they did not create anxiety or stress for the learners, nor any competitiveness between them. Not only did the activities provide a mechanism for the learners to practice the fluency they were developing through other activities of the club but they also provided me, as researcher and mentor, with a quick way of evaluating, encouraging and valuing learner progress. In a paper written during this study (Stott & Graven, 2013a), I explore further how supplementary learner reflections made the use of these activities more holistic for the learners in the sense that they were able to reflect on their own progress in mathematics. I also explore the use of these reflections by one learner in section 5.4 later in this chapter.

5.3.2 FLUENCY ASSESSMENT RESULTS: ELMTREE PREP

Figure 19 shows that the club average for first set of fluency tests (administered in March 2012) had a 79% completion rate and a 94% accuracy score. In the second set of tests (administered in August 2012), the club average completion rate had increased by 18 percentage points to 97% and the accuracy score by 4 percentage points to 98% across all the tests for the six club learners in Table 27 below. Thus the learners overall have increased their speed of completion.

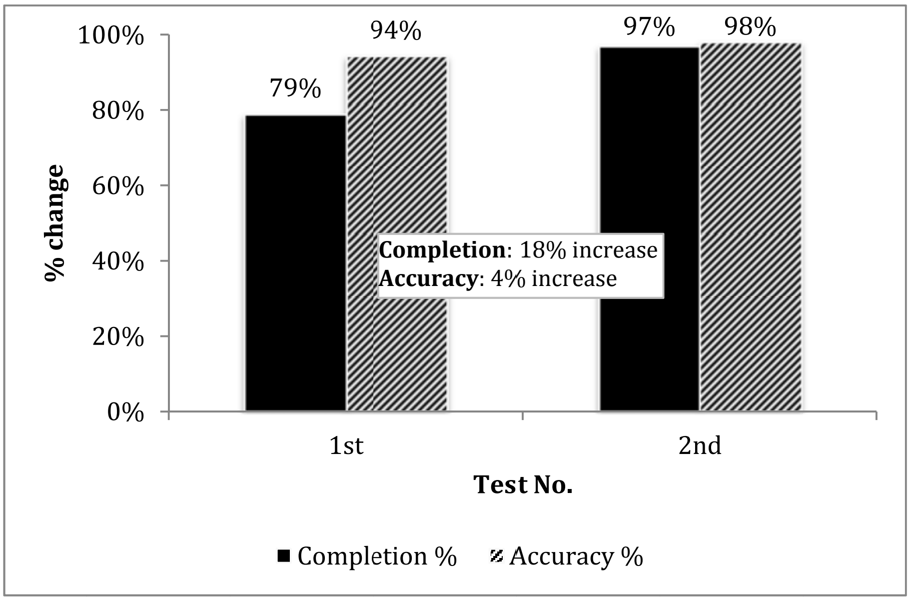


Figure 19: Overall club fluency assessment averages: completion & accuracy - Elmtree Prep (six learners)

From the scores shown in Table 27, I highlight some results worth noting across the six club learners at the Elmtree Prep club who completed both sets of assessments. For Zac, Thembela and Zintle accuracy reduced slightly in some of the second round tests. Anathi, Kholeka and Cebisa for the most part maintained and increased both their completion rates and accuracy over time. Zac's results are mixed. Having increased his completion rate in *add and subtract to 10 and 100*, his accuracy lowered on these. On the other hand, he maintained his completion rate in *doubling* and *halving* and achieved 100% accuracy for *halving*. Thembela's results showed substantial increases in completion for *add and subtract to 10 and 100* (50 and 60 percentage points respectively), although this increased speed seemed to affect her accuracy for *add and subtract to 10.* However, she achieved 100% accuracy in the other three tests. Zintle also shows significant increases in the number of items answered in 3 tests and has made slight increases in accuracy in two tests. Her accuracy on *halving* however has decreased slightly. The increase in completion and accuracy scores pointed to improved efficiency and procedural fluency, which could be as a result of the work I did in the club on strengthening the basic facts listed in the Methodology chapter. The data pointed to these learners becoming faster at both writing and recalling the basic facts with little compromise to accuracy as this mostly increased across the tests and learners as well.

Table 27: % change for each learner for each fluency assessment in Elmtree Prep

	% ANSWERED (COMPLETION)			% ACCURACY			TRADITIONAL SCORE		
Learner / test	**1st test**	**2nd test**	**% Change**	**1st test**	**2nd test**	**% Change**	**1st test**	**2nd test**	**% change**
Anathi			***20%***			***3.75%***			***22%***
Add & subtract 10	35%	95%	60%	86%	100%	14%	30%	95%	65%
Add & subtract 100	80%	100%	20%	94%	95%	1%	75%	95%	20%
Doubling	100%	100%	0%	100%	100%	0%	100%	100%	0%
Halving	100%	100%	0%	100%	100%	0%	100%	100%	0%
Cebisa			***6.5%***			***4.5%***			***10%***
Add & subtract 10	80%	95%	15%	88%	100%	13%	70%	95%	25%
Add & subtract 100	95%	100%	5%	95%	100%	5%	90%	100%	10%
Doubling	100%	100%	0%	100%	100%	0%	100%	100%	0%
Halving	94%	100%	6%	94%	94%	0%	88%	94%	6%
Kholeka			***1.5%***			***5%***			***7%***
Add & subtract 10	95%	100%	5%	95%	100%	5%	90%	100%	10%
Add & subtract 100	100%	95%	-5%	85%	100%	15%	85%	95%	10%
Doubling	94%	100%	6%	100%	100%	0%	94%	100%	6%
Halving	100%	100%	0%	100%	100%	0%	100%	100%	0%
Zac			***11.25%***			***-2.25%***			***11%***
Add & subtract 10	70%	100%	30%	100%	90%	-10%	70%	95%	25%
Add & subtract 100	85%	100%	15%	100%	95%	-5%	85%	95%	10%
Doubling	100%	100%	0%	100%	100%	0%	100%	100%	0%
Halving	100%	100%	0%	94%	100%	6%	94%	100%	6%
Thembela			***27.5%***			***5%***			***25%***
Add & subtract 10	35%	85%	50%	100%	94%	-6%	35%	80%	45%
Add & subtract 100	35%	95%	60%	86%	100%	14%	30%	95%	65%
Doubling	100%	100%	0%	94%	100%	6%	94%	100%	6%
Halving	100%	100%	0%	94%	100%	6%	94%	100%	6%
Zintle			***31%***			***1.25%***			***29%***
Add & subtract 10	45%	75%	30%	100%	100%	0%	45%	75%	30%
Add & subtract 100	50%	85%	35%	90%	94%	4%	45%	80%	35%
Doubling	47%	100%	53%	88%	94%	7%	41%	94%	53%
Halving	88%	94%	6%	100%	94%	-6%	88%	88%	0%

Note: Nate was absent when the second set of tests were administered, thus none of his scores are included.

5.3.3 FLUENCY ASSESSMENT RESULTS: LUHLAZA PRIMARY

Figure 20 shows that the club average for the first set of fluency tests (administered in March 2012) had a 46% completion rate and 64% accuracy score. In the second set of tests (administered in July 2012), overall the club average completion rate increased by 22 percentage points to 68% and the accuracy score by 19 percentage points to 83%.

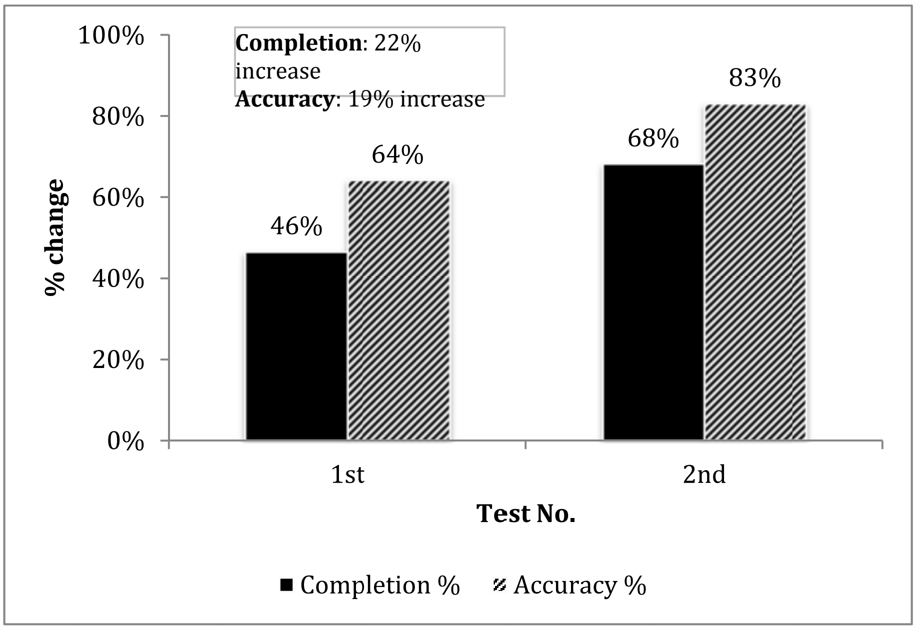


Figure 20: Overall club fluency assessment averages: completion & accuracy - Luhlaza Primary (ten learners)

From the progress for each of the ten learners in March and July 2012 shown in Table 28 below, I highlight some notable results.

Although all learners increased their average speed of completion across all tests in the second round, only two learners (Kuhle and Sipho C) completed any tests (as shown by 100% completion for *halving* and *add & subtract 10*). Other learners such as Chebe, Khule and Sipho N made noteworthy improvements in completion with an average completion rate across all tests of 31, 35 and 30 percentage points respectively.

Looking at individual test, different learners made different gains in completion speed. For example Khule showed a 60% improvement in the *add and subtract 100* test. However, some learners completed less than they did in the first round of tests. See for example Akhona, Emi, Oma, Sipho C, Aphiwe and Apolo.

With regards to accuracy, all learners apart from Sipho N and Apolo show positive progress on average across their four tests. Noteworthy examples are Chebe and Akhona with an average accuracy % change of 40% or more. However, Sipho N's substantive increases in completion for the *halving* and *add and subtract 100* tests had a detrimental effect on his accuracy which showed negative change. The only test where he shows positive progress for both completion and accuracy is for the *add and subtract 10* test.

Other learners for example Akhona, Oma and Sipho C showed regression with regards to accuracy in at least one test. For example Siphiwe and Emi in *add and subtract 10*. Apolo's results are worth looking at. He showed a 65% improvement in his *add and subtract 10* test but in both rounds of tests, he failed to achieve accurate answers for any test except *halving* and his traditional scores additionally showed that he made no progress over time in these fluency assessments.

As with Elmtree Prep, the increases in completion and accuracy scores pointed to improved efficiency and procedural fluency for the majority of learners and could be as a result of the work I did in the club on strengthening the basic facts listed in the Methodology chapter. With some individual exceptions (such as Apolo), the data pointed to learners becoming faster at both writing and recalling the basic facts with little compromise to accuracy as this mostly increased across the tests and learners as well.

Table 28: % change for each learner for each fluency assessment in Luhlaza Primary

	% ANSWERED (COMPLETION)			% ACCURACY			TRADITIONAL SCORE		
Learner / test	**1st test**	**2nd test**	**% Change**	**1st test**	**2nd test**	**% Change**	**1st test**	**2nd test**	**% change**
Akhona			***18%***			***40%***			***36%***
Add & subtract 10	30%	25%	-5%	50%	100%	50%	15%	25%	10%
Add & subtract 100	40%	95%	55%	25%	100%	75%	10%	95%	85%
Doubling	59%	71%	12%	90%	100%	10%	53%	71%	19%
Halving	76%	88%	12%	69%	93%	24%	53%	82%	29%
Chebe			***31%***			***44%***			***36%***
Add & subtract 10	15%	60%	45%	0%	83%	83%	0%	50%	50%
Add & subtract 100	20%	70%	50%	0%	93%	93%	0%	65%	65%
Doubling	71%	94%	23%	100%	94%	-6%	71%	88%	17%
Halving	82%	88%	6%	93%	100%	7%	76%	88%	12%
Khule			***35%***			***3%***			***34%***
Add & subtract 10	35%	85%	50%	86%	94%	8%	30%	80%	50%
Add & subtract 100	40%	100%	60%	100%	80%	-20%	40%	80%	40%
Doubling	76%	88%	12%	85%	100%	15%	65%	88%	23%
Halving	82%	100%	18%	93%	100%	7%	76%	100%	24%
Emi			***22%***			***14%***			***30%***
Add & subtract 10	10%	30%	20%	100%	17%	-83%	10%	5%	-5%
Add & subtract 100	45%	35%	-10%	11%	86%	75%	5%	30%	25%
Doubling	41%	94%	53%	29%	100%	71%	12%	94%	82%
Halving	47%	71%	24%	100%	92%	-8%	47%	65%	18%
Oma			***15%***			***16%***			***19%***
Add & subtract 10	40%	55%	15%	63%	100%	37%	25%	55%	30%
Add & subtract 100	45%	85%	40%	67%	71%	4%	30%	60%	30%
Doubling	59%	71%	12%	70%	92%	22%	41%	65%	24%
Halving	82%	76%	-6%	100%	100%	0%	82%	76%	-6%
Sipho C			***20%***			***15%***			***29%***
Add & subtract 10	65%	70%	5%	54%	100%	46%	35%	70%	35%
Add & subtract 100	45%	95%	50%	89%	95%	6%	40%	90%	50%
Doubling	82%	76%	-6%	93%	100%	7%	76%	76%	0%
Halving	71%	100%	29%	92%	94%	2%	65%	94%	29%
Sipho N			***30%***			***-2%***			***21%***
Add & subtract 10	25%	55%	30%	60%	82%	22%	15%	45%	30%
Add & subtract 100	45%	95%	50%	78%	63%	-15%	35%	60%	25%
Doubling	59%	65%	6%	100%	91%	-9%	59%	59%	0%
Halving	41%	76%	35%	100%	92%	-8%	41%	71%	30%
Aphiwe			***13%***			***36%***			***33%***
Add & subtract 10	10%	50%	40%	100%	80%	-20%	10%	40%	30%
Add & subtract 100	40%	80%	40%	0%	63%	63%	0%	50%	50%
Doubling	41%	47%	6%	86%	88%	2%	35%	41%	6%
Halving	82%	47%	-35%	0%	100%	100%	0%	47%	47%
Apolo			***11%***			***-3%***			***-12%***
Add & subtract 10	15%	80%	65%	0%	0%	0%	0%	0%	0%
Add & subtract 100	10%	35%	25%	0%	0%	0%	0%	0%	0%
Doubling	65%	41%	-24%	91%	71%	-20%	59%	29%	-30%
Halving	82%	59%	-23%	93%	100%	7%	76%	59%	-17%
Siphiwe			***22%***			***27%***			***22%***
Add & subtract 10	5%	35%	30%	100%	57%	-43%	5%	20%	15%
Add & subtract 100	25%	30%	5%	0%	50%	50%	0%	15%	15%
Doubling	6%	59%	53%	0%	100%	100%	0%	59%	59%
Halving	47%	47%	0%	100%	100%	0%	47%	47%	0%

5.3.4 FLUENCY ASSESSMENT RESULTS: SUMMARY ACROSS BOTH CLUBS

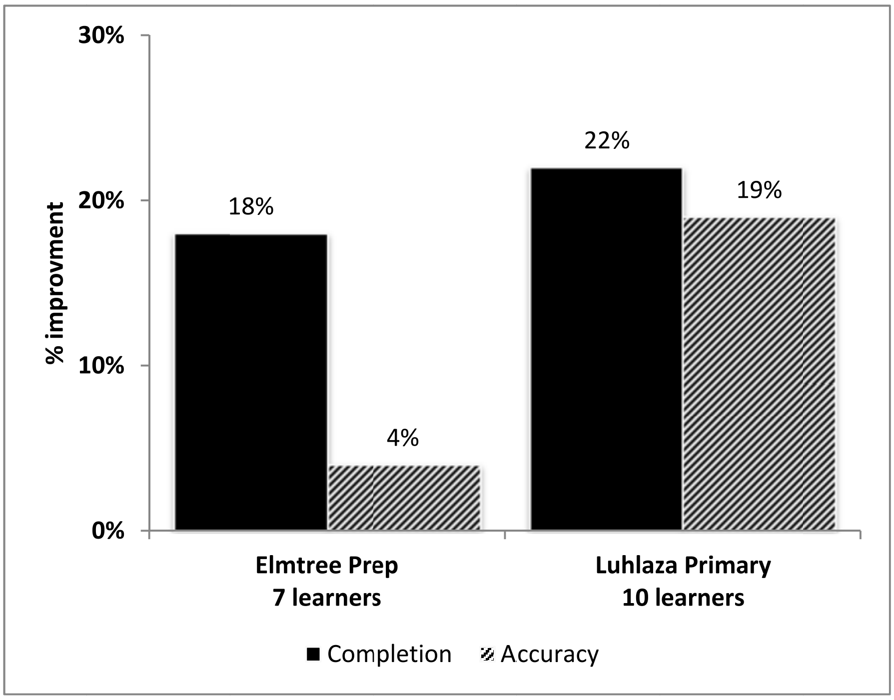


Figure 21: Fluency assessments club comparison: overall % change for completion & accuracy

While fluency was assessed over a shorter period (March to July) than the MP interviews, the fluency assessments showed that across both clubs learners on average completed more in one minute in the second set of tests, and were more accurate. Significant increases in speed (completion) for both clubs as shown in Figure 21 were 18% and 22% respectively. Luhlaza Primary had a noteworthy increase in accuracy (19%). This was due to several learners making substantial improvements in accuracy in the second round of tests.

While these fluency activities measured speed and accuracy (as explained in Chapter Four), this fluency was not developed by doing these activities *per se*, but more likely as a result of using other sense making and flexible thinking activities promoted in the clubs, such as the number talks and games discussed in Chapter Three. Earlier, I spoke of *deliberate practice* (Askew, 2002; Pegg, 2010) as a way of developing fluency. This can occur when we set a time limit or work with bigger numbers in activities, thereby making the practice harder. The fundamental point of deliberate practice is to continually stretch the learner to just beyond his or her current abilities. The games played in the clubs aimed to facilitate deliberate practice in developing fluency. In addition, these timed fluency activities were a form of deliberate practice for the learners, whilst focusing on the efficiency and accuracy aspects of the *procedural fluency* definition (Kilpatrick et al., 2001).

The data from the MP interviews and fluency assessments presented in this chapter provided a useful picture of learner mathematical progress from different perspectives: how accurately they answered the interview tasks as evidenced by the interview scores, their progress in solving problems in more efficient and sophisticated ways as evidenced by their LFIN profile and how they progressed in comparison to the club group as a whole. However, in the presentation of data in these comparative ways, the richness of learner stories is often lost or ignored.

Thus in order to illuminate individual learner progress with more depth and richness, I provide a narrative vignette of one case study learner (Thembela) across these instruments. I have purposefully selected her story for a number of reasons. Her results in both the MP interview and the fluency assessments showed progress and she was a participant in the task-based interviews undertaken for research question two. Furthermore, she was the learner who exhibited the most visible stress when using the fluency assessments for the first time. Her story is enlightening as it illuminates the ethical tensions arsing from the use of these instruments and how I dealt with this. In addition, as a supplement to this story, I was fortunate to have an ad-hoc interview with Thembela’s mother in August 2013, where she shared some of her insights into Thembela’s participation in the club.

In this vignette I share the story of Thembela’s progress across assessments over time to illustrate a number of insights. Firstly, the vignette reveals how the two different data collection instruments worked together to reveal overall learner progress. Secondly, the story illustrates the type of progress the club learners made over time and finally exemplifies the role that reflection can play in learning. In order to write a story of Thembela’s progress, I have extracted her data from the previous sections and used this data as the basis for the narrative that follows.

5.4 THEMBELA'S STORY: A NARRATIVE VIGNETTE

Thembela was a regular attendee at the Elmtree Prep club. In the first half of the year, she sought my attention and chatted to others (about non mathematical events) more than she participated in the mathematics activities of the club. In the second half of the year, she engaged more actively and in a focused way with the activities, worked well when asked to work in pairs and she discussed mathematical ideas with myself and other club participants.

In the March interview, Thembela's scores for all LFIN aspects (except structuring numbers 1 to 20) were below the club average and ranged from 71% to 85%. However, results from the November interview showed that her results were above or the same as the club averages for all LFIN aspects, achieving 100% in all but early arithmetic strategies. The percentage change from the March interview to the November interview showed that Thembela achieved the highest percentage point change of all club learners for number words and numerals and for early arithmetic strategies. Thembela's progress in early arithmetic strategies is notable as she was below the club average for this aspect in March. Her results also showed substantial progress for conceptual place value and early multiplication and division. While Thembela scored lowest on the March interview, she made the greatest progress in scores in the November interview.

Her progress in LFIN levels was also interesting. She moved one level in *conceptual place value* and *early arithmetic strategies* and a minimum of two levels in *number words and numerals*. This progress showed a number of things. Firstly, although her methods were getting more sophisticated as seen from her progress in conceptual place value and early arithmetic strategies, she still had room to progress further. Secondly, in her second MP interview she demonstrated elements of procedural fluency by working out answers mentally. Her ability to locate numbers on the number line and to see the patterns in numbers revealed that she was developing some level of conceptual understanding and by verbalising her thinking, she was beginning to reason adaptively. In the time between the two MP interviews, Thembela appeared to have made progress in her ability to work accurately by using mental processes where appropriate and in consolidating her understanding of various concepts, thus showing the she was developing several elements of mathematical proficiency.

Thembela's progress in the fluency assessments was substantial. Across all the fluency assessments, her completion rate increased by 27.5 percentage points which was the second highest improvement in this club. Additionally across all the assessments, her accuracy increased by 5 percentage points which was the joint highest improvement in the club. In July, she also increased her completion rate in '*add / subtract 10*' and was the first club learner to finish the '*halving*' activity, which she answered 100% accurately (research journal, 31st July 2012). She was 100% accurate in *add / subtract 100, doubling* and *halving* and finished both the doubling and halving assessments in the allotted time (research journal, 31st July 2012). Her increase in speed in the '*add / subtract 10'* assessment however, was accompanied by some negative regression on her accuracy for this test.

However a more important aspect of her story is revealed in a reflection that she undertook on these fluency assessments in July. There is no doubt that for Thembela, the introduction of the timed fluency activities into Elmtree Prep caused some anxiety. (Thembela's written reflection is shown in Appendix G). I noted in my research journal (13th March 2012) that during my first use of the fluency activities in March, Thembela was quietly tearful, displaying anxiety about not knowing an answer and she remained tearful for the remainder of the activity. I encouraged her to continue and to complete all the activities and afterwards I had a group discussion about the purpose of the activities and a reminder of the club ethos. For example, I spoke about being supportive of each other and re-stated that mistakes are opportunities to learn.

When the fluency activities were re-administered in July, Thembela showed a less emotional attitude towards the activities, even showing excitement after the '*add / subtract 100 activity*' saying with a tone of pride "just one more to go and I would have been finished". She completed all but one of the possible sums and answered all those she completed accurately. This showed progress from March when she only answered 7 of the possible 20 questions and correctly answered 6 of these. She reflected on this activity as her biggest improvement. In the discussion following the completion of the July activities, Thembela mentioned crying in her March assessments and said that she "was better this time" (research journal, 31st July 2012).

Thembela's changed attitude towards the timed activities in July showed. Her reflection response to "*what has helped you make progress*?" was "practising and undastading" (sic). She also reflected on her effort as her reason for improvement "because I have worked very hard". Her reflection on why she made progress was revealing in that it drew together the notions of procedural fluency, conceptual understanding and the productive disposition element of steady effort (Kilpatrick et al., 2001). It seemed from Thembela's response that she saw practising and understanding as connected. Her comment about working hard perhaps showed signs of her developing a positive *productive disposition* towards mathematics as it foregrounded steady effort. Her comment perhaps reflected an emerging belief (and experience) in steady effort in maths paying off.

These notions of changing confidence, effort and attitude were echoed by her mother who told me that prior to joining the club, Thembela "didn't like to work with numbers" and was "reluctant to do her maths homework". However, after joining the club, Thembela was more motivated and keen to do her maths homework and she was able to do her homework independently. Her mother said:

> *The attitude also changed… it was one of the biggest things that I noticed, which I think is a big thing when it comes to our children, the attitude you have towards a certain subject* (30th August 2013).

Thembela's confidence and attitude changed over the period of a few months as noted from her reflection on the fluency assessments. This confidence and change in attitude was accompanied by her engaging more deeply and enthusiastically in club activities and reflects in the progress she made in the November MP interview. Kilpatrick et al. (2001) assert that the strands of mathematical proficiency develop alongside each other and are interwoven. Thembela's story supports this assertion.

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5.5 DISCUSSION AND INSIGHTS

Research question one: how do learners' mathematical proficiency levels evolve (if at all) over the period of participation in the maths club?

The intention of this chapter has been to present and analyse the data and discuss findings to address research question one. The data collected from the instruments and the analysis framework and filters used allowed me to review how club learner mathematical proficiency levels evolved in three different ways. Firstly, the generation of the MP interview scores for the LFIN allowed me to make comparisons over time of the number of questions answered correctly for individual learners. Further, the scores gave me a broad picture of each club's progress as a whole and allowed comparison across the two case study clubs. Secondly, progression through LFIN levels / stages along learning pathways was revealed through the individual learner profiles. Finally, I have pointed to the emerging development of three strands of mathematical proficiency (conceptual understanding, procedural fluency and adaptive reasoning) in club learners through this analysis.

In addition to being able to address the research question, this chapter has provided insights with regard to the relationship between the LIFN, the strands of mathematical proficiency and fluency; and the scoring system I developed for the MP interview. By extracting indicators for conceptual understanding, procedural fluency and adaptive reasoning from Kilpatrick et al.'s (2001) work, I was able to weave the broader notions of these strands of mathematical proficiency into the analysis of the MP interviews, by finding instances or absences where learners exhibited or failed to exhibit elements from the indicators. This in turn showed how the strands connect across the LFIN aspects and allowed a richer description to emerge in the presentation and analysis of the data.

As stated previously, the LFIN stages and levels represent increasing sophistication and efficiency for each aspect, thus providing a learning pathway for each learner's mathematical learning in specific early number concepts such as conceptual place value. By overlaying these stages and levels with mathematical proficiency indicators for conceptual understanding, procedural fluency and adaptive reasoning, a more connected picture arose. I was able to show how the LFIN aspects were connected by the broader mathematical strands of proficiency and how deeper mathematical thinking develops. Thus, the strands of mathematical proficiency form an umbrella over the LFIN and the elements of fluency to pull everything together. The LFIN therefore provides us with typical learning pathways for mathematical learning in specific early number concepts whilst the five strands offer a broader notion of developing mathematical proficiency over time and beyond early number. This idea is illustrated in Figure 22 below, foregrounding the three strands featured in this analysis.

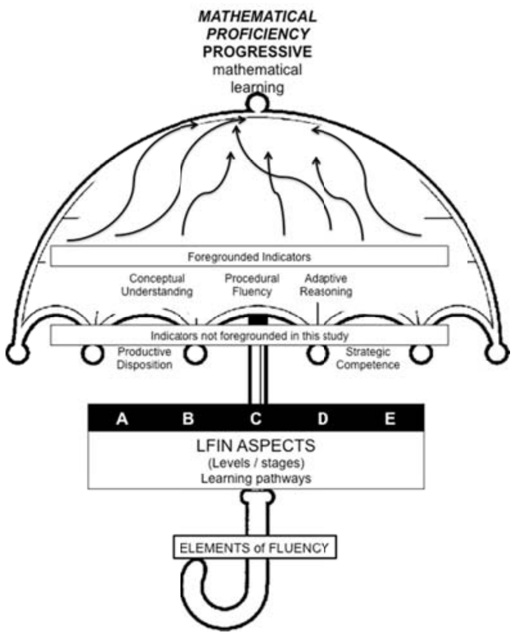


Figure 22: The relationship between three strands of mathematical proficiency, the LFIN and fluency

The second insight relates to my use of a scoring system for the MP interviews (details of this are discussed in Chapter Four). The creators of the MR programme never intended for the assessment interview to result in a score. The data from the interview has always been used to profile each individual learner on the LFIN. In my study and in the running of the clubs over the research period, I found that using a combination of scores and the methods learners used to answer questions (as noted on their interview scripts) invaluable for both planning purposes and for analysis of progress made over time.

5.6 CHAPTER FIVE: CLOSING REMARKS

In using the interview and LFIN components from the Maths Recovery programme (Wright, Martland, Stafford, et al., 2006; Wright, 2003) in a South African context I have developed some valuable insights into how the various components work. Although the structure of the interview was adapted to include some additional tasks as discussed in

Chapter Four, I used the interview as intended as a one-one interview with South African leaners but with some extension to the scoring system.

The combination of data derived from the LFIN and the fluency assessments proved to be effective in allowing me to gauge mathematical proficiency progress through the levels for each aspect and for determining where I needed to work with each learner. Furthermore, the LFIN also provided me with an analysis framework for this research question as well as a structured way of reporting on the data collected for this question.

However, one drawback that I encountered was the time it took to work out which levels to place the learners at, even though I was working with a relatively small amount of learners. I suggest that it would be difficult for teachers to use the entire interview to profile learners on the LFIN for a whole class and suggest further research is required in the South African context on how to administer these interviews and how to profile learners on their mathematical learning pathways.

In the following chapter I present the data for research question two using the analysis frameworks of attention catching mechanisms, mediation and the ZPD.

---- END OF CHAPTER FIVE ---

CHAPTER 6 THE NATURE OF MEDIATION - PRESENTATION, ANALYSIS AND DISCUSSION OF FINDINGS

Research question two: What is the nature of the mediation that enables or constrains the emergence of a ZPD in learners in the clubs?

6.1 INTRODUCTION AND CHAPTER OUTLINE

The focus for this chapter and research question is the nature of mediation and how this enabled or constrained the emergence of ZPDs for club learners. As described in Chapter Four, in order to answer this research question, I carried out paired mediation sessions in the form of task-based interviews in the two clubs. The Luhlaza Primary interviews were carried out in August 2012 and the Elmtree Prep interviews in October of 2012. Two learners participated in each interview, which took approximately 45 minutes to an hour. Each task-based interview was video-recorded and then transcribed, giving me a video corpus from which to work. The entire video corpus was transcribed. After viewing the entire video corpus, I selected particular segments of video for further analysis. I then conducted a quantitative analysis using various indicators to get an overview of what was prevalent across all the selected episodes. Using the broad analysis as a springboard I then chose further smaller segments or episodes, which I used for rich and detailed qualitative analysis.

In previous chapters I have indicated that data analysis is a process of searching for meaning so that what is learned can be communicated to others (Hatch, 2002 cited in Leech & Onwuegbuzie, 2007). I also highlighted that Lerman (2000 p.36) spoke of research as a zoom lens as a way of finding a way to take account of the other elements which come into focus throughout the zoom thus emphasising the importance of looking at all dimensions and not just fragments of the research situation (Lerman, 1998, p. 67). Since it would be cumbersome to present and talk about video transcripts in their entirety it was therefore necessary to select parts of the transcript that illuminate various key insights as central discussion items.

But what of the remainder of the transcripts? With Lerman's zoom lens metaphor in mind, I suggest that one way of looking at all dimensions and not just fragments of data is by taking a combined qualitative and quantifiable approach to the analysis and presentation of the data under consideration. I thus approach this chapter from these perspectives. I zoom out to gain a broad sense of the data for the three selected episodes. I subsequently zoom back in on certain aspects of the data to highlight key insights that arise from the data and to use these to provide illustrations for arguments that I am making. As this is a qualitative study, I acknowledge that these presented episodes do not count as evidence in and of themselves, but rather they provide supporting evidence and illustrations for arguments that are being made (Denscombe, 2010). For clarity in the presentation of this analysis, I have structured this chapter as follows:

Section 6.2

This section includes discussion of the guiding analysis principles I have used for this chapter. These focus on attention catching mechanisms and mediation.

Section 6.3

This section details a description of the task used in chosen segments of the task-based interviews and describes the learners who participated in the interviews, the terminology and conventions used throughout this chapter.

Section 6.4

Using matrices and graphs, I examine the predominant *modes of social interactions* between three pairs of learners and the two mentors, the predominant *attention catching mechanisms* evident and the predominant *mediating practices* used. This section is largely quantitative, drawing on frequencies of coded indicators from the full transcripts of the three selected video episodes. A key aim of this section was to find patterns and discover relationships in the data to enable me to make comparisons across episodes and pairs of learners. A discussion at the end of this section pulls together the findings from this broad analysis that enabled me to make decisions about where to deepen the subsequent qualitative analysis. Thus this quantifiable analysis informs the detailed, rich and fine-grained analysis of selected video segments in section 6.5.

Section 6.5

Building on the quantitative data from section 6.4, this central section of the chapter presents the rich, fine-detailed qualitative analysis of selected video segments that addresses this research question. In this section I study a number of key events from each episode and analyse the nature of the mediation in each. Using mediation and it’s relationship to attention catching between participants, I examine how this enabled or constrained the emergence of ZPDs for the club learners.

Section 6.6

In this section, I summarise the overall findings for this research question, bringing together findings from both the broad qualitative analysis and the detailed quantitative analysis. I focus on key findings from the data under four headings: tuning in, attention catching and mediation, sustainment of ZPDs and the relationship between the ZPD, new learning and consolidation of existing learning. I also 'talk back' to some of the theoretical aspects of the ZPD presented in Chapter Two.

Broader data from which data and analysis in the chapter is drawn is provided in Appendix J, whilst the full transcripts for the three episodes under analysis are available in Appendix I.

6.2 GUIDING PRINCIPLES FOR THIS CHAPTER

The task-based interviews were used as an instrument to collect data for the second research question. Primarily I was interested in the nature of mediation that took place in the club sessions and how this enabled or constrained the emergence and sustainment of ZPDs in the club learners. More specifically I examined how participants caught each other's attention and the overall nature of mediation.

Recall that Meira and Lerman (2001, 2009) argued that a ZPD may emerge when participants catch each other's attention and sustain that attention. This was therefore the starting point for my analysis. If I could establish how attention catching occurred between the participants in each mediated activity, perhaps I would then be able to determine if and when a ZPD emerged. With respect to attention catching then, I was guided by the following questions:

- In what ways did the participants in the interviews catch each other's attention and how did they subsequently communicate mathematical reasoning and ideas to each other?
- What sense could I make of catching attention in the club-learning environment?
- Once attention was caught, was it sustained and how?
- If attention was not caught, why not? Did a ZPD emerge as a result of this attention catching?
- If a ZPD did not emerge, what usefulness did the learning activity have?

- Finally, what were the most frequently used mediating practices and which of these appear to be most effective (based on Anghileri's (2006) hierarchy of scaffolding)?

6.3 ORIENTATION TO EPISODES, TASK, TERMINOLOGY AND CONVENTIONS USED IN THE TASK-BASED INTERVIEWS

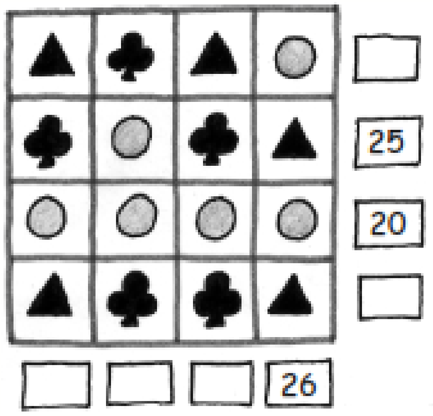
As indicated in Chapter Four, the task-based interviews consisted of three tasks. The entire video corpus available for analysis was thus approximately four hours in length. After watching this video corpus I decided to focus only on Task 3 in full for the boys and girls interviewed at Elmtree Prep and for the girls[32] interviewed at Luhlaza Primary. I chose to select this task for analysis because none of the learners had seen a puzzle such as this before and the task was therefore an example of a problem solving activity. Also, such 'unseen' problem solving activities were regularly given to the learners to work on in pairs in club sessions. It was an opportunity to observe how mediation helped the learners approach such a problem-solving task. Additionally, by focusing on a single task across the interviews I was also able to contrast mediating interactions across pairs and facilitators.

The details of each interview are discussed in detail in Chapter Four, however for clarity, the selected episodes are:

- **Episode One** takes place at the Elmtree Prep club. Two girls were interviewed, *Anathi* and *Thembela*. I facilitated the interview. The episode was approximately 47 minutes in length.
- **Episode Two** takes place at the Elmtree Prep club. Two boys were interviewed, *Nate* and *Zac*. *Mellony* facilitated the interview. The episode was approximately 42 minutes in length.
- **Episode Three** takes place at the Luhlaza Primary club. Two girls were interviewed, *Akhona* and *Kuhle*. I facilitated the interview. The episode was approximately 45 minutes in length.

As a reminder Task 3 from the task-based interview is shown in Figure 23 below:

[32] Two boys were also interviewed at Luhlaza Primary. As explained in Chapter Four, there was unfortunately no audio for the task 3 video of the interview and I was thus not able to use for analysis.



In this grid, each shape stands for a number.

The numbers shown are the totals of the line of four numbers in the row or column.
Find the remaining totals.
Say what number each shape stands for.

Figure 23: Task 3 from the task-based interviews

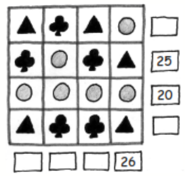
Terminology and notation conventions used in this chapter

Video recordings of interactions need to be translated into another medium to facilitate detailed analysis and to facilitate accurate sharing of data. The most common medium is a transcript, which I use as the main method of presentation in this chapter. This chapter includes transcript excerpts for the selected critical events.

The terminology and conventions I use in my transcriptions emerged as most useful for my study based on my needs for answering this research question. In choosing my terms and transcript conventions I drew on Goldman et al. (2007) as well as aspects that emerged as important in my initial observations of video; for example the importance of gestures in catching attention. The conventions and key terms for the transcriptions are detailed in Table 29 below. Each convention and term is described specifically as used in this study. An annotated transcript (Figure 24 below) follows illustrating the conventions and terms in the context of a transcript excerpt.

Additionally as I explained in Chapter Four, Mellony Graven and myself facilitated the four task-based interviews. The club learners knew both Mellony and myself as club mentors. As such, I use our first names and I have chosen to use the word ‘mentor’ rather than facilitator throughout this chapter to refer to our roles. Furthermore, I refer to myself in the first person in the descriptions that follow. In the following section of this chapter I present a broad quantitative analysis across the three selected episodes.

Table 29: Terminology used in chapter six

Term	Description	Indicated as:	Comments
Video corpus	As described in the Methodology Chapter, the task-based interviews consisted of the same three tasks for both clubs. The video corpus is made up of 4 task-based interviews between 40 and 50 minutes each.	Task-based interviews at: Elmtree Prep Girls: approx. 47 minutes in length Boys: approx. 42 minutes in length Luhlaza Primary Girls: approx. 45 minutes in length Boys: approx. 43 minutes in length (no audio)	
Task	One of three tasks presented in the task-based interviews	Task Three from the task-based interview is the chosen task under analysis in this chapter	 More detail on this task above and in Chapter Four
Episode	The full transcripts for the selected task for a particular task-based interview	Episode One: Elmtree Prep: Girls Episode Two: Elmtree Prep: Boys Episode Three: Luhlaza Primary: Girls	This could also be thought of as segments of the video corpus.
Critical Event	Selected turns in an episode that reflect **significant** moments in the episode. An event is called critical when it demonstrates a **significant or contrasting change from previous understanding or a conceptual leap from earlier understanding**	For each episode, see these pages for a list of critical events: Episode One: page 228 Episode Two: page 242 Episode 3: page 254	This provides evidence for important theoretical or analytic matters relative to my guiding research question
Transcript line number	Number of each new line in the transcript	These are numbered in the 2nd column of the transcript	
Turn	A communicational unit of analysis, that encapsulates the social interactions that arise during the episode	These are numbered in the 3rd column of the transcript.	Includes: speech, posture, gaze, gesture, action and expression
Participant	Name of the participant	A grey shaded box with white text in the ***Speaker column*** indicates where learners contribute to the interactions. For example ANATHI & THEMBELA	

Term	Description	Indicated as:	Comments
Mode of social interaction	Social interaction codes which focus on the verbal and non-verbal data in the episode. These include: *speech*, *posture*, *gaze*, *expression* and *action*.	These are shown in the 4th column of the transcript.	More information is given and in the Methodology chapter.
What is said and what is done	What the participants say and do in the video.	Normal text indicates *verbal speech* Text in bold and italics describes ***non-verbal interactions*** such as gestures, expressions, actions etc.	
Attention Catching Mechanism (ACM)	ACM codes generated during the analysis phase	Light grey shaded box with black text and a double border indicates the coded ACM. The numbers in brackets indicate the transcript line number(s). For example: L expressing something in direct response to m question (334)	A full list of attention catching mechanisms is available in the Methodology Chapter.
What happens after attention is caught	This column in the transcript indicates a relationship between the ACM and what follows after attention is caught.	Dark grey shaded box with white text and a double border indicates a relationship between the ACM and what happens after attention is caught. The numbers in brackets indicate the transcript line number(s). For example: M attention caught by learner expressing something (51/2)	
Mediating Practice	Mediating practice codes	Normal text indicates that mediation takes place but does not follow attention being caught. The number in brackets following the mediating practice indicates Anghileri's level i.e. 1, 2 or 3 White text in a black box indicates where mediation follows attention caught. For example: Encouraging (1)	From Anghileri's (2006) scaffolding practices as described in Methodology Chapter.

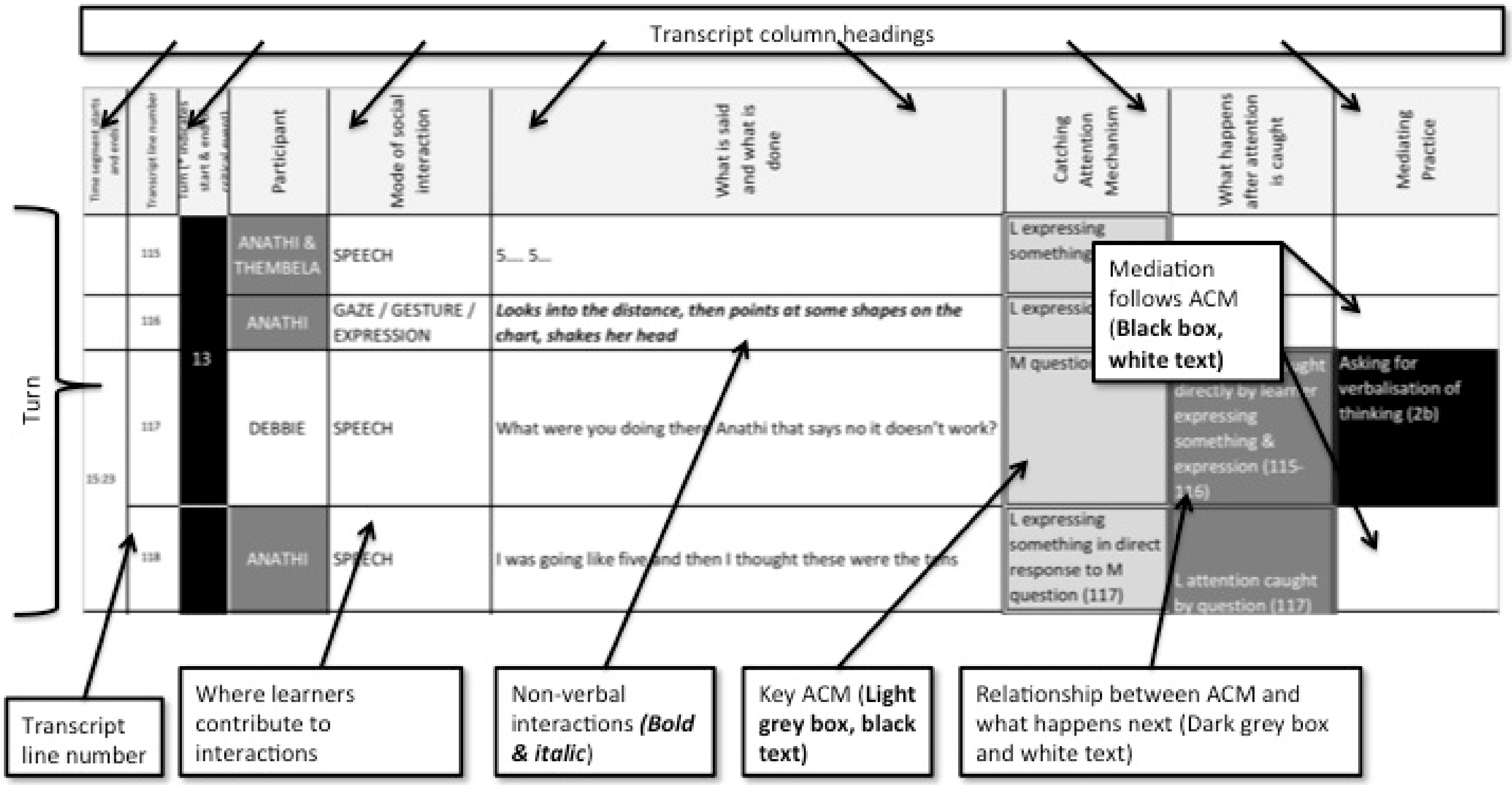


Figure 24: Conventions and terms used in transcripts informed by Goldman et al. (2007)

6.4 BROAD QUALITATIVE ANALYSIS OF THREE SELECTED EPISODES

Although the data for this research question is qualitative, in this first section of the analysis I zoom out to explore my data in a largely quantifiable manner. In this section, I use graphs as a way of contrasting the patterns of interactions between the participants, attention catching mechanisms and mediation used by the participants in the three selected episodes. These graphs derive from matrices generated from the full episode transcripts (available in Appendix I). Using the coding structures in the transcripts, I used matrices and graphs to provide data for analysis in three ways:

i. An analysis of the predominant *modes of the social interactions* that took place between the participants across the episode as a whole
ii. An analysis of the predominant *types of attention catching mechanisms* that were evident in the episodes
iii. An analysis of the prevalent *mediating practices* that mentors used in the episodes

These coding structures and resultant matrices and graphs enabled me to find patterns in the large amount of video and transcript data, in much the same way that the tables and graphs did for research question one, and enabled me to discover relationships in the data. Thus I was able to make comparisons across episodes and pairs of learners and to point to where I could deepen my analysis using a qualitative approach.

I discuss each of the analyses in the section that follows by first looking at a graph that summarises across all three episodes. Matrices generated for each individual episode that form the data for the graph can be found in Appendix J. The broad quantitative analysis focuses on three pairs of learners working on Task 3 in the task-based interviews. I conclude this section with a discussion of the findings from this broad quantification of i, ii and iii above and how these findings inform the subsequent fine-grained qualitative analysis of selected video segments (or events).

i. Modes of social interaction in Episodes One, Two and Three

As described in Chapter Four, I analysed the *modes of social interactions* across all three episodes as a whole using the mode of social interaction codes (see Table 48, Table 49 and Table 50 in Appendix J for the detailed data). In this section I summarise the modes of social interactions across all three episodes using two graphs:

- Instances of modes of social interaction for *learners* across all episodes (Figure 25)
- Instances of modes of social interactions for *mentors* across all episodes (Figure 26)

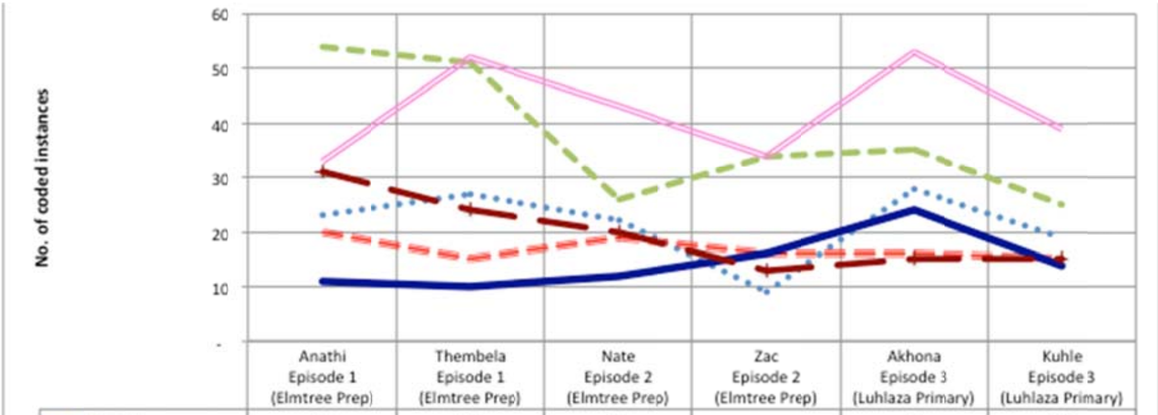
These graphs focus on the verbal and non-verbal data in the episodes. Codes include: *speech*, *posture* (including body movements such as dancing, throwing arms into the air etc.), *gaze* (direct eye contact between participants), *gesture* (using hands to do something i.e. pointing to something, touching), *expression* (including laughter, frowning, nodding etc.) and *action* (mathematical writing on paper, calculating using fingers etc.).

An analysis of the range of *social interactions* used by the participants in each episode assisted my detailed analysis in various ways. The learners participating in the task-based interviews were grade 3 learners and their capabilities to articulate themselves fully in spoken language were still in the early stages of development. This analysis therefore allowed me to identify the forms of verbal and non-verbal interactions revealed in each episode and in the final analysis, to establish whether these were pivotal to the creation of balanced (symmetrical) communication between the participants. Mercer and Dawes (2008) state that many interactions taking place in the classroom can be described as ‘asymmetrical’ when the teacher “leads the interaction and has the privilege, and responsibility, of being in control” (p. 55). Similarly, interactions in the ZPD can be asymmetrical in nature (Lerman, 2001; Roth & Radford, 2010) if it is perceived that one participant has more competence or power than the other(s). I acknowledge here that as mentors, Mellony and myself would naturally have more mathematical competence or power than the learners, however our intention was to maintain balanced dialogue with learners.

The development of a matrix enabled me to indicate whether the learners and the two mentors maintained a balanced or asymmetrical dialogue and interactions. In addition, the matrix helped me to identify the predominant types of social interaction each of the participants displayed in the episode and the extent of learners’ reliance on verbal or non-verbal interaction. This analysis does not however show whether attention was caught between the participants and what the nature of the mediation was. As hypothesised, these were pivotal to the emergence of a ZPD. Later matrices address these aspects.

Modes of social interaction across episodes

The following graph (Figure 25) summarises across all episodes the number of coded instances of modes of social interactions for the *six learners*. Mentor interactions are shown separately in Figure 26 below.



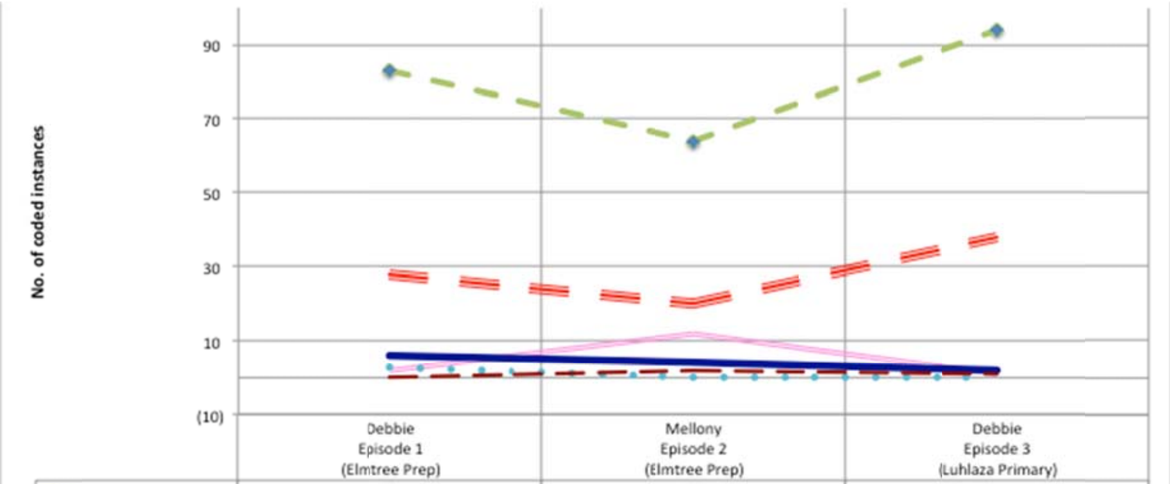
	Anathi Episode 1 (Elmtree Prep)	Thembela Episode 1 (Elmtree Prep)	Nate Episode 2 (Elmtree Prep)	Zac Episode 2 (Elmtree Prep)	Akhona Episode 3 (Luhlaza Primary)	Kuhle Episode 3 (Luhlaza Primary)
Speech	54	51	26	34	35	25
Gaze	33	52	43	34	53	39
Posture	23	27	22	9	28	19
Gesture	20	15	19	16	16	15
Mathematical Action	11	10	12	16	24	14
Expression	31	24	20	13	15	15
TOTALS	172	179	142	122	171	127

Figure 25: Instances of modes of social interaction for learners (across all 3 episodes)

Looking at the total interactions, I note that Thembela, Anathi and Akhona had over 170 coded total interactions in their episodes, indicating that they interacted more than the other learners in this activity. Anathi and Thembela also had the highest instances of speech interactions and I examine this more closely in the next section on attention catching mechanisms (ACMs). Zac and Kuhle had the lowest number of total coded interactions. *Speech-based* (green dashed line) and *gaze-based* (double pink line) interactions are the predominant modes of interaction for all learners.

Akhona and Thembela showed the highest number of coded *gaze-based* interactions. Another notable observation is that Zac (Elmtree Prep) and Akhona (Luhlaza Primary) showed the highest use of *mathematical action* (e.g. workings on paper) of the six learners.

The following graph (Figure 26) summarises, across all three episodes, the number of coded instances of modes of social interactions for the *mentors*.



	Debbie Episode 1 (Elmtree Prep)	Mellony Episode 2 (Elmtree Prep)	Debbie Episode 3 (Luhlaza Primary)
Speech	83	64	94
Gaze	2	12	1
Posture	3	-	-
Gesture	28	20	38
Mathematical Action	6	4	2
Expression	-	2	1
TOTALS	122	102	136

Figure 26: Instances of modes of social interactions for mentors (across all 3 episodes)

I had the most total interactions in Episode Three (Luhlaza Primary: Girls) while Mellony had the smallest number of total interactions (Episode Two at Elmtree Prep: Boys). The graph indicates that as was the case with the learners, *speech-based* interaction (green dashed line) was the predominant mode for both mentors across all the episodes. This was followed by *gesture-based* interactions (triple red dashed line). Examples of gestures used by both Mellony and myself were: pointing to an aspect of the activity or learner workings on scrap paper; gesturing towards a learner; emphasising with hands and touching learners on the shoulder, hand or back. It is interesting to note the similarity in the high frequency of speech and gestures used by Mellony and myself. In the next sub-section I focus on coded *attention catching mechanisms* across all three episodes.

ii. Attention Catching Mechanisms in Episodes One, Two and Three

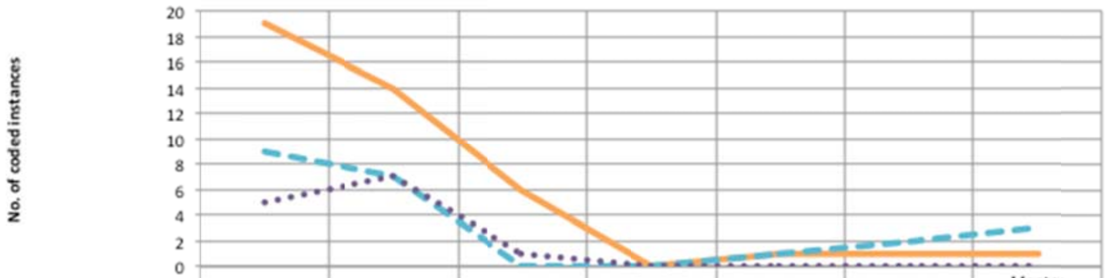
The second broad analysis is a summary of the *types of attention catching mechanisms* that are revealed in each episode (see Table 51, Table 52 and Table 53 in Appendix J). Attention catching mechanisms (ACMs) can be thought of as ways that the participants catch each other's attention and communicate mathematical ideas and reasoning to each other and they are of particular interest because they often lead to the emergence of a ZPD (Meira & Lerman, 2001, 2009). Recall the ACMs codes that arose in this study were given in Table 21 in Chapter Four.

In this section I summarise the mediating practices across all three episodes using two graphs:

- Instances of attention catching of *learners by mentors* across episodes (Figure 27)
- Instances of attention catching of *mentors by learners* across episodes (Figure 28)

Attention Catching Mechanisms (ACMs) across all episodes

In the graphs below, I have subtitled headings as *verbal* and *non-verbal* ACMs. *Verbal* ACMs are attention-catching mechanisms that are a result of verbal (or speech-based) communication such as questions, statements and when learners express themselves. *Non-verbal* ACMs are those that originate from gesture, gaze, postural positions and changes and so on.

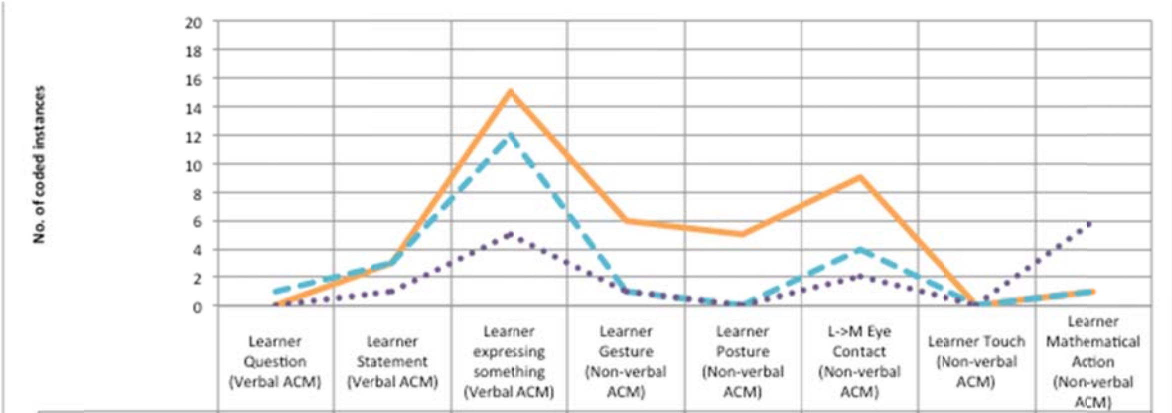


	Mentor Question (Verbal ACM)	Mentor Statement (Verbal ACM)	Mentor Gesture (Non-verbal ACM)	Mentor Posture (Non-verbal ACM)	Task Itself (Non-verbal ACM)	Mentor Touch (Non-verbal ACM)	Mentor Mathematical Action (Non-verbal ACM)
Episode 1 (Elmtree Prep)	19	14	6	0	1	1	1
Episode 2 (Elmtree Prep)	9	7	0	0	1	2	3
Episode 3 (Luhlaza Primary)	5	7	1	0	0	0	0
TOTALS	33	28	7	0	2	3	4

Figure 27: Instances where mentors catch learners attention (across all 3 episodes)

The graph in Figure 27 shows the instances where mentors caught learners' attention across all three episodes. Mentor initiated *questions* and *statements* had the most coded instances with totals of 33 and 28 instances respectively. The majority of these were in Episodes One and Two (both Elmtree Prep). This suggests that verbal mechanisms were the predominant means by which mentors caught the learners' attention. Of note, was that the *task* itself caught the learners' attention at the beginning for both the boys and girls at Elmtree Prep whereas this was not the case for the girls in Episode Three. Overall the total mentor initiated ACMs shown in this graph for Episode Three at Luhlaza Primary (with 13 instances) were much lower that those for Episodes One (42 instances) and Two (29 instances) at Elmtree Prep.

The graph in Figure 28 below shows the coded instances where learners caught the mentors attention.



	Learner Question (Verbal ACM)	Learner Statement (Verbal ACM)	Learner expressing something (Verbal ACM)	Learner Gesture (Non-verbal ACM)	Learner Posture (Non-verbal ACM)	L->M Eye Contact (Non-verbal ACM)	Learner Touch (Non-verbal ACM)	Learner Mathematical Action (Non-verbal ACM)
Episode 1 (Elmtree Prep)	0	3	15	6	5	9	0	1
Episode 2 (Elmtree Prep)	1	3	12	1	0	4	0	1
Episode 3 (Luhlaza Primary)	0	1	5	1	0	2	0	6
TOTALS	1	7	32	8	5	15	0	8

Figure 28: Instances where learners catch mentors attention (across all 3 episodes)

The predominant mechanism used by learners to catch the mentors' attention across the episodes with 32 instances in total was that of *learners expressing something*. 27 of these instances occur in the two Elmtree Prep episodes. *Learner-to-mentor eye contact* is shown as the second most prevalent way that learners catch the mentors' attention with 15 instances in total across the three episodes.

As this analysis revealed that *learners expressing something* was the predominant way by which learners caught mentor attention, I was prompted to explore the relationship between this and their speech-based interactions. I asked if the high frequency of speech interactions acted as attention catching mechanisms for both the learners and mentors. I investigate this below.

Speaking and attention catching

Recall from the modes of interaction graph that Anathi, Thembela and Zac (all at Elmtree Prep) had the highest *speech-based* interaction out of the six learners. I analyse these two aspects in more detail in Table 30 below to investigate if there was any relationship between speech and this resulting in catching attention. The table is split into two: the left side examines *learner speech* and verbal ACMs and the right side examines *mentor speech* and verbal ACMs. Each side shows:

1. The number of coded instances of *speech* as a mode of interaction. For the learners I combined their instances of speech into a single number.
2. The number of coded instances of speech that are also coded as *verbal* ACMs (*questions, statements* and *learners expressing something*).
3. The difference between the two numbers expressed as a fraction and a percentage of the coded instances of speech.

Table 30: Instances of speaking and resulting in attention catching for learners and mentors in each episode

	LEARNERS			**MENTORS**		
Episode and learners	**Combined coded instances of speech**	**No. of speech instances that resulted in mentor's attention being caught**	**Fraction / Percentage**	**Coded instances of speech**	**No. of speech instances that resulted in at least one learner's attention being caught**	**Fraction / Percentage**
One (Anathi, Thembela & Debbie)	105	18	Just over one sixth / 17%	83	33	Just over a third / 40%
Two (Zac, Nate & Mellony)	60	16	Just over a quarter / 27%	64	23	Just over a third / 36%
Three (Akhona, Kuhle & Debbie)	60	6	One tenth / 10%	94	12	Just over a tenth / 13%
Totals	225	40	Just under a fifth / 17%	241	68	Just over a quarter / 28%

Learner speech catching mentors' attention

Across all three episodes, just under one fifth of learner speech (17%) resulted in catching the mentor's attention. The highest learners' percentage was Zac and Nate, with just over a quarter of their speech catching Mellony's attention while for Akhona and Kuhle only one tenth of their speech catches my attention. This suggests that much of what the learners said in these interviews did not capture the mentors' attention in any significant way and led me to ask what else the learners used this talk for.

I noted that learners used their talk for reasons such as 'thinking aloud' or what Barnes (2008, p. 4) calls "exploratory talk". He describes this type of talk as hesitant and incomplete because it enables the speaker to try out ideas and to "arrange information and ideas into different patterns" (p. 4). Exploratory talk enables the speaker to sort out his or her own thoughts and perhaps gives the learner the opportunity to "talk their way into understanding" (Barnes, 2010, p. 9). It may be the case that Akhona and Kuhle have restricted opportunities to express themselves in this manner or were not confident with expressing themselves mathematically or in English inner talk. With regard to the higher frequency of mentor talk than learner talk in the three episodes, I explore why this may occur in the discussion at the end of this section.

Looking at the individual episodes however, the figures tell a different story. The two boys at Elmtree Prep had 60 instances of learner *speech-based* contributions but just over a quarter of these contributions (16) resulted in catching Mellony's attention. At Luhlaza Primary, the number of coded *speech-based* contributions of Akhona and Kuhle were the same as those for Nate and Zac at Elmtree Prep but these speech contributions only caught my attention in six coded instances. This led me to ask what the boys said differently to the Luhlaza Primary girls and how they said it.

A close analysis of the ACMs for the two boys in Episode Two revealed that even though Nate's speech contributions were lower than Zac's, the instances where Nate said something or expressed himself, caught Mellony's attention slightly more often. During the episode, neither boy spoke unless he had something specifically mathematical to say as shown in the examples in Table 31 below. Nate spoke with mathematical direction and clarity as shown in the first two examples below but he also used speech to express that he has realised something (see lines 67, 95, 192 and 284 below).

Table 31: Examples of Nate's and Zac's speech from Episode 2 transcript

Examples of Nate's speech (Episode 2)	Examples of Zac's speech (Episode 2)
Well, I was counting, so what equals… so 10, 18 plus what equals 26? And I just counted on … in 8s (line 208) I was saying that the triangle and circle was wrong so they would have to be a different number (line 151) Ooh (line 67), oh (line 95), hey (line 192), aaah (line 284)	So this will be 10 and 10 that will be 20. This will be 3 and 2 (line 62) This will work out … 5, 10, 15, 20 (line 65) This is gonna have to be 5 (line 73) Yes, and that will be 25 (line 102)

Further examination of Akhona and Kuhle's speech contributions from Episode Three showed different patterns of speech to those of the boys. In all 6 coded instances, it was only Akhona's speech that caught my attention. Akhona tried to explain her mathematical thinking as evidenced in the examples shown in Table 32 below and she also used short one-word answers such as Yes and No to questions asked by myself. Kuhle did not speak often (two examples are shown below) or gave single number answers (see lines 148, 212 and 325 as examples).

Table 32: Examples of Akhona's and Kuhle's speech from Episode 3 transcript

Examples of Akhona's speech (Episode 3)	Examples of Kuhle's speech (Episode 3)
That is 5 plus 5. 10 plus 5 (line 54) I want a half (line 175) Noo, I'll find the answer of here (line 261) I want the answer of those, of those together (line 265)	We don't know these numbers (line 99) I halved 26 (line 239) 13 (line 148) 16 (line 212) 12 (line 325)

These differences in what learners say and how they say it could be one reason why attention was caught or not.

Mentor speech catching learners' attention

Looking now at the mentors' side of Table 30 above, just over one quarter of mentor speech across all episodes resulted in catching learners' attention. For both episodes at Elmtree Prep, I note that approximately a third of mentor speech resulted in catching learner attention. The verbal catching attention mechanisms that the mentors used were mostly *questions* and *statements* (see tables in Appendix J). In contrast, the fraction of mentor speech resulting in catching the learners' attention in the Luhlaza Primary episode was just over a tenth. Similarly to the learners, this suggested that much mentor talk did not catch these learner's attention.

Final words

A key insight from this analysis was that speaking as an attention catching mechanism can thus be differentiated in two ways. One form of speech acts as a *mathematical* attention catching mechanism that potentially enables pulling a learner into a ZPD and can operate between learners and mentors and between learners themselves. The other form of speech behaves as a more *general* attention catching mechanism that keeps learners on track or focused on the task at hand. This issue is explored more deeply in the discussion at the end of this section.

iii. Mediating Practices in Episodes One, Two and Three

Finally, I summarise the coded *mediating practices* used by Mellony and myself as mentors in these episodes (see Table 55, Table 56 and Table 57 in Appendix J). In this section I summarise the mediating practices across all three episodes using a graph. The graph is structured according to Anghileri's (2006) hierarchy of mediating practices discussed in Chapter Four. In the coding process I labelled her level 2 practices into 3 sub-levels using 2a, 2b and 2c in order get a finer grained analysis of practices used. Thus these are referred to as follows:

- **Level 2a – Funnelling:** Guiding learners towards a pre-determined solution
- **Level 2b – Reviewing:** Clarification of learners' understanding
- **Level 2c – Restructuring:** Taking learner understanding forward

Mediating practices across all episodes

The annotated graph in Figure 29 below illustrates the mediating practices used across all three episodes. I discuss the more effective mediating practices (according to Anghileri, 2006) of *Reviewing* (level 2b), *Restructuring* (level 2c) and *Developing Conceptual Thinking* (level 3) in the discussion below and they are shown to the right of the solid black line on the graph.

The graph clearly shows that *reviewing* (level 2b) practices were the most prevalent form of mediation with a total of coded 100 instances across all episodes. *Funnelling* practices (level 2a) were the second most frequent (49 instances in total), followed by *environmental provisions* (with 36 instances). There was some evidence that *restructuring* (level 2c) and *developing conceptual thinking* (level 3) practices were used in several instances in all three episodes with a total of 19 instances each.

Looking at the predominant practices for each episode, *reviewing* practices (level2b) were predominant in both episodes from Elmtree Prep (Anathi / Thembela and Zac / Nate) with 50 and 21 instances respectively. *Funnelling* practices (level 2a) with 32 instances were the predominant practice for Akhona and Kuhle in Episode Three.

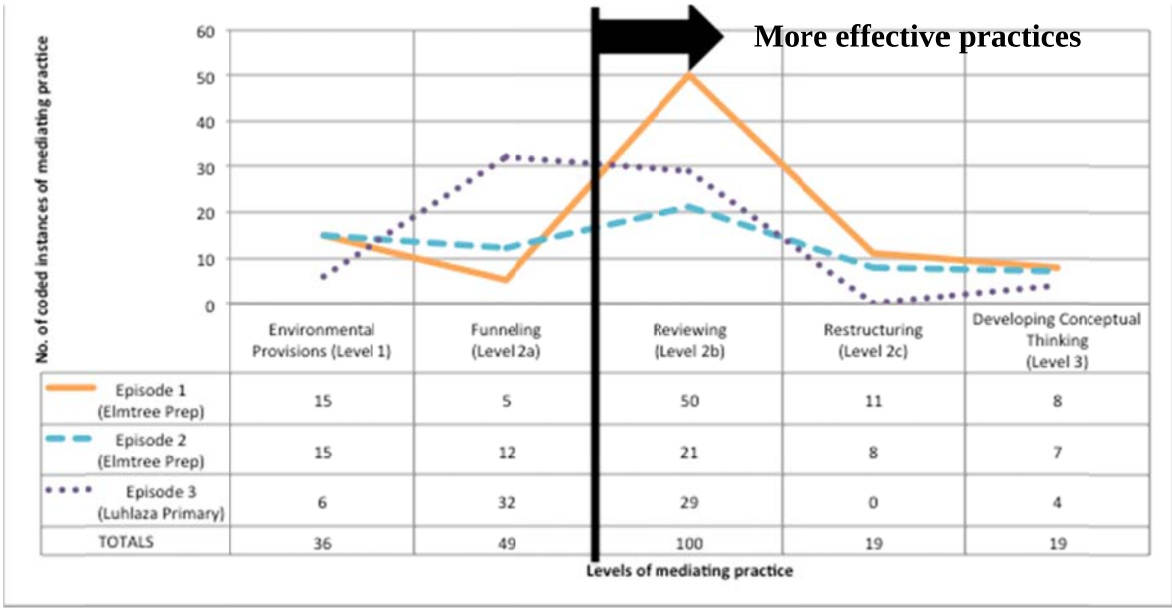


Figure 29: Instances of mediating practice (across all 3 episodes)

In the following discussion, I review this broad quantification of the various mediating practices, attention catching mechanisms and modes of social interaction.

6.4.1 BROAD ANALYSIS DISCUSSION

Below I pull together the patterns of data that arise from the various matrices and graphs. This discussion informs the more detailed, richer qualitative analysis that follows in the next section. A number of insights were gained from exploring this data in this manner. These insights relate to: the relationship between speaking and attention catching, the range of modes of interaction and ACMs revealed and the predominant nature of the mediation across the three episodes. I discuss each of these insights in turn.

Speaking and attention catching

Analysing the balance of dialogue in a video episode is not as simple as counting the number of turns of speech and can be looked at in several different ways. For example one could analyse the amount of time spent talking (or count the number of words spoken), count the number of turns or code each participants speech contributions as I have chosen to do here. Furthermore one can compare individual learner speech contributions against mentor speech contributions or compare combined paired-learner speech contributions against those of the mentor. In this analysis, I have chosen to compare combined paired-learner speech contributions against those of Mellony and myself as the intention of the task-based interviews was for the learners to work together as a pair and for us to maintain a balanced dialogue.

Mellony and myself (as mentors), somewhat predictably, used *speech-based* interaction as our primary mode of interaction. In the girls Elmtree Prep episode, mentor speech was less than Anathi and Thembela’s combined (105 instances combined and 83 mentor instances[33]) whilst speech in the boys Elmtree Prep episode was relatively balanced between the two learners and Mellony (with 60 learner instances and 64 mentor instances). However in the Luhlaza Primary episode, I spoke much in more turns than Akhona and Kuhle (60 instances combined and 94 mentor instances). This suggests that there was some asymmetry in the dialogue between participants at Luhlaza Primary (Lerman, 2001; Mercer & Dawes, 2008; Roth & Radford, 2010) in Episode Three.

In line with the club ethos, one of the stated intentions prior to undertaking the task-based interviews was that the tasks, undertaken in pairs, would elicit learner talk. In other words

[33] See Appendix J for the tables detailing these interaction for each participant.

we encouraged the learners to talk as much as possible about their mathematical reasoning and ideas. It is interesting that my *speech-based* interactions were higher than those of the learners in Episode Three. This analysis revealed that I was not as successful as we had hoped in this regard as I spoke substantially more than the two learners in this episode. One reason for the predominance of mentor talk could be that in this episode I was required to use more "traditional" (Anghileri, 2006, p. 41) mediational practices such as explaining and telling in some instances. This is borne out from the analysis of mediating practices for this episode and is discussed in the section on mediating practices below.

The graphs presented show that both learners and mentors however also used a range of other *non-verbal* means to communicate their thoughts and ideas. For the learners, the coding revealed that half of the learners relied predominantly on *speech* (Anathi, Thembela and Zac, all from Elmtree Prep) and half predominantly on *gaze* (Nate, Akhona and Kuhle) as their primary modes of interaction. These modes were reversed for the secondary modes of interaction, making *speech* and *gaze-based* interactions the most commonly used in all the episodes for the learners.

The verbal ACMs represented the number of times attention was caught using some form of *speech-based* interaction. Generally this was via *questions*, *statements* or *learners expressing something* making up 64%[34] of the total ACMs across the episodes. Even though I noted (in Table 30 above) that overall there was a substantial difference between speech-based interactions and speaking to catch attention, verbal ACMs were still the predominant mechanism for catching attention in these episodes.

The preceding analysis of modes in social interaction suggests that talk is indeed a predominant way of interacting between the participants in these selected episodes. I argued earlier that the data revealed two discernable types of attention catching mechanisms, which could point to an extension of Meira and Lerman's (2009) work on attention catching. These, as explained above, were firstly as a *mathematical* attention catching mechanism that could enable the emergence or sustainment of a ZPD and secondly as one that behaved as a more *general* attention catching mechanism that kept learners on track or focused on the task at hand.

[34] A summary table of the ACMs across all three episodes is shown in Appendix J on page 347

Range of modes of interactions and ACMs

As noted, across the three episodes participants used a wide range of social modes of interaction but predominately a combination of speech and gaze. Recall, as mentors, our faces were rarely seen in the video as the focus was on the learners. As only visible interactions were coded, it was therefore not possible to determine the extent of *gaze-based* interaction used by the Mellony and myself. Similarly, I counted the mentor-initiated *gaze-based* interactions that could be seen on the video or clearly inferred based on how a learner reacted to Mellony or myself. Both Mellony and myself used *gestures* as our second most frequent mode of interaction.

These speech and gaze modes were echoed in the predominant coded ACMs. Mellony and myself primarily used *questions* and *statements* to catch learner attention and learners primarily verbally *expressed* themselves to gain our attention and the attention of the other learner in the interview. Of particular note was that the *task itself,* when placed on the table in front of the learners, was captivating enough to act as an initial ACM for the learners in both Elmtree Prep episodes. This suggests that the choice of task, which was a central consideration when planning, allowed learners to engage with the task prior to any verbal mediation or other attention catching taking place. However, this was not the case with Akhona and Kuhle at Luhlaza Primary who tended to wait for instructions before they engaged with the task in front of them. This was possibly due to the different teaching styles and classroom practice norms across the two classes. I explore this idea further in the discussion at the end of this chapter.

The non-verbal ACM of *eye contact* (which can be related to *gaze-based* interaction) made up 13%[35] of the total ACMs of Mellony, the six learners and myself and was the most common non-verbal ACM. The analysis shows that this ACM is evident between learners themselves and between learners and mentors. I have made a distinction between eye contact and glancing for the purposes of this analysis. Eye contact is held, done with awareness and indicates engagement. The reasons for this will become clear in the analysis of Episode Three later in this chapter.

[35] A summary table of the ACMs across all three episodes is shown in Appendix J on page 377

Gestures were used by the learners in the interviews in two ways: firstly as a means of focussing their own attention on something specific in the activity and secondly as a way of showing emphasis (for example after having said something). Both Mellony and myself used *gestures* as our second most frequent mode of interaction and *gesture* was thus additionally a frequent ACM for both learners and mentors. As I indicated previously, both Mellony and myself used gestures as ways to draw learners' attention to specific aspects of the activity or to include learners in the activity. Using touch to draw them into the activity was one example.

Predominant mediating practices

The analysis above revealed the predominant mediating practice as *Reviewing* (level 2b) with 100 instances or 44.8%[36] of the total coded mediation practices. Furthermore, the analysis showed that these reviewing practices were generally centred on clarifying the learners' understanding of the mathematics they encountered in this task. As Anghileri (2006) suggested, enabling learners to develop their own meanings using mediation of this kind can have "long-term benefits in enhancing their confidence and independence in learning" (p 42). However, having established these as the predominant practices, I explored the effectiveness of these mediating practices for mathematics learning.

Anghileri (2006) suggested that teachers will be most effective in the mathematics classroom if they are able to use a range of teaching approaches that encourage *active* involvement of the learners. In describing her scaffolding hierarchy, she maintained that the *effective* practices such a reviewing, restructuring and developing conceptual thinking allow teachers to respond flexibly to the contributions that learners make during mathematical activities by being more responsive to learners. She argued that many teachers rely on 'non-effective' funnelling type practices which include directing, telling and explaining. These types of practices echo what Askew et al. (1997) noted as the 'transmission orientation' of teaching mathematics which consists of clear verbal explanations of routines and following of the teacher's instructions.

In the second level of her hierarchy, Anghileri argued that *reviewing* and *restructuring* are more effective level two practices whilst *making connections* and *generating conceptual*

[36] See Table 58 on page 384

discourse are more effective at the third level[37]. She argued that a combination of these more effective practices should be used to encourage *active* involvement of learners in the mathematics classroom. Her reasoning resonated with the results from the Effective Teachers of Numeracy study (Askew et al., 1997) which explained that a *connectionist* orientation towards teaching tends to be the most effective. This orientation focused on dialogue between teacher and learners as a way to explore understandings, as well as placing a firm emphasis on developing reasoning and justification.

Table 58 in Appendix J summaries the mediating practices coded across the three episodes. From this table and from Anghileri's (2006) point of view, *effective* mediating practices across episodes make up 61.9% of the total mediational practices, which constitutes well over half of the practices evident in the video episodes. 44.8% of these 'effective' mediation practices focus on *reviewing* (level 2b), while 17% fall within the *restructuring* (level 2c) and *development of conceptual thinking* levels. The remaining 38.1% encompass *environmental* and *funnelling* practices which Anghileri considers to be less effective practices.

Mediatory practices used by both Mellony and myself included clarifying, excavating and prompting which helped the learners in the interviews to focus on specific mathematical points. Seeking justification in turn encouraged the learners' to think while making learner talk and actions explicit drew learner attention to their mathematical strategies and actions. If as Anghileri (2006) argued these are effective mediating practices, then from the analysis so far, I suggest that the use of 'effective' mediation practices dominated across these episodes. The girls' episode at Elmtree Prep (Anathi and Thembela) showed the highest occurrence of the use of effective mediation practices making up over half of the *reviewing* (50%) and *restructuring* (58%) practices coded across all three episodes. The Luhlaza Primary episode (Akhona and Kuhle) showed the lowest occurrence of the use of effective mediation practices with over 65% of the coded practices for this episode being *funnelling* type practices.

There are various possible reasons why the mediation in the Luhlaza episode reflected a high frequency of funnelling practices. I noted in my research journal that it took the

[37] Note a summary of the practices used for this analysis and the levels I have labelled appear in the Methodology chapter and in Appendix F.

learners at the Luhlaza Primary club a lot longer to feel comfortable about talking mathematically in the club environment. I wrote that the learners were "getting used to talking and explaining, especially the girls" (31st May 2012). I noted that a breakthrough took place in the 13th club session in July when the boys and girls began to talk to each other, began to ask each other questions and explain their thinking to each other and not just to me as mentor (Journal entry, 26th July 2012). My perception of the learners' discomfort with verbal interaction could account for the predominance of funnelling practices (including explaining, directing and telling as evidenced in the matrices for this episode) in the interviews which took place August.

In talking about the ZPD, Roth and Radford (2010) pointed out:

> *In each interaction, teachers can find out whether something they have done or said was or was not successful, and whether their subsequent attempts in changing their actions/utterances bring about the appropriate response. This situation is in fact very common in the classroom … Far from constituting a sole opportunity for the student to learn (e.g., subject matter), the zone of proximal development constitutes an opportunity for the teacher to learn too (p. 304).*

Indeed, this resonated with my own experience in the task-based interviews and could be another reason for the predominance of different mediation practices I used between the girls' episode at Luhlaza Primary (August) and the girls episode at Elmtree Prep (October). Roth and Radford (2010) pointed out that a teacher's actions and discourse become more refined as she moves from one group of learners to another; in other words she is learning which actions are more effective and what are the best things to say to direct learners' attention. This is something that I felt myself when I carried out the second round of interviews. I was more confident with the structure of the interview and felt that I had learnt to some extent when to allow learners to work without intervention and when to intervene.

I also wish to highlight the surprisingly high occurrence of environmental provision type mediation practices (36 coded instances, 16.1% of the total coded practices) revealed by this analysis. In my analysis, the majority if these were of the *encouragement* type (for example valuing learner contributions). For this study, this came to light through the analysis of mediating practices but also through the analysis of speech and verbal attention catching mechanisms discussed earlier. This concurs with a study by Bliss, Askew and

Macrae (1996) who found that scaffolding practices based on approval, encouragement, structuring work, or organising people were the most commonly used. Often these types of mediation practices have no direct mathematical relevance but serve a supportive function. I have pointed to this being the case in this analysis.

Summary

These overall insights from the analysis of these three episodes provided a broad picture of various aspects of the task-based interviews and set the scene for the qualitative analysis that follows. However, the power of this wider analysis was revealed in the data for each *individual* episode as this uncovered some marked variations that did not follow the broader patterns presented so far. The variances highlighted in the individual episodes enabled me to determine where to focus in the ensuing analysis. As an example of these variations, I note just a few of these differences.

The characteristics of Akhona's and particularly Kuhle's mathematical speech were somewhat different to those of the four learners in the other episodes and their speech did not result in catching my attention nor did it result in a mathematical dialogue, characterised by flexible mediation. The mediation offered for Anathi and Thembela at Elmtree Prep was focussed on clarifying their understanding of the mathematics whilst for the girls at Luhlaza Primary the mediation was generally centred on *funnelling* type practices which include directing, explaining and so on. For Zac and Nate at Elmtree Prep, their speech was generally mathematically focussed and in their episode, they used this speech not only to catch Mellony's attention but also each others and their own attention (to maintain focus). Thus *learners expressing something* was a key way that learners gained mentor and peer attention.

In the remainder of this chapter, I delve more deeply into the qualitative analysis for question two and zoom in to examine several critical events for each selected episode. I explain why each event was chosen and for each have described what was happening in the event. I was guided by the questions presented in section 6.2 and have centred my discussion on those, looking at the nature of the mediation and how this is related to the attention being caught between the participants. At the end of each series of events I focus on key insights from the events.

6.5 CATCHING ATTENTION AND MEDIATION: HOW DO THESE ENABLE OR CONSTRAIN THE CREATION (AND / OR SUSTAINMENT) OF ZPDS?

Using the patterns revealed from the indicators in the previous section to inform a richer, more in-depth analysis, in this section I present a number of events from the selected episodes discussed previously. For each episode, I have selected three to four critical events that exemplify how attention catching and mediation enabled or constrained the emergence and sustainment of ZPDs in the six club learners who participated in the task-based interviews drawing primarily on Meira and Lerman's work (2009). A critical event contains selected turns in an episode that reflect significant moments in the episode. An event is called critical when it demonstrates a significant or contrasting change from previous understanding or a conceptual leap from earlier understanding[38].

This section is structured similarly for each episode. For each critical event I thus:

- Briefly describe why the event has been chosen
- Introduce what takes place before the critical event in order to contextualise it
- Present the transcript segment for the critical event
- Analyse what is happening in the transcript
- Tell the story of how attention catching and mediation emerges in the critical event

Thereafter, I highlight the insights that emerged from the series of events for the episode.

[38] This term arose during a discussion with Prof Lerman about the structure of my transcripts in 2013

EPISODE ONE: ANATHI & THEMBELA (GIRLS) AT ELMTREE PREP

The insights from the broad analyses of the episodes presented in the previous section point to deeper analysis of three critical events for Episode One. As analytical discussions, these were purposefully selected because of their potential for exemplification of the following:

1. Attention caught by the task and initial problem solving steps
   Turns 1 to 6 (start of the task, lines 1 to 43)
2. Sustained task engagement and further attention catching
   Turns 19 to 22 (6 minutes into the task, lines 168 to 205)
3. Mediation as attention catching mechanisms
   Turns 37 to 45 (just over 8 minutes into the task, lines 297 to 354)

Introduction to the critical events for Episode One

I facilitated this episode between Anathi and Thembela. The episode starts 37 minutes into the task-based interview and the girls had already completed tasks one and two. The critical event below starts with turn one and the introduction of the task to the girls. Anathi finds a value for the circle in 33 seconds and it jointly takes Anathi and Thembela 9 minutes and 42 seconds to complete the task.

Note: in this episode the girls and I refer to the club shape on the puzzle alternately as “flies” or “trees”.

Critical event 1: Attention caught by task and initial problem solving steps

This event was chosen to exemplify how the task quickly catches the learners' attention and how that interest helps Anathi find the value for circle quickly. The event begins when I place task three in front of the girls.

Time	Line Number	Turn	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
12:43	1	*1	DEBBIE	ACTION	***Places the activity sheet on the desk between the girls***	Activity		
	2		DEBBIE	SPEECH	Let's try the last thing, which is this thing. Ooh. Okay. Lovely.	M statement	L attention caught by activity (1 [39])	Setting the scene (1)
	3		ANATHI & THEMBELA	POSTURE / EXPRESSION / GAZE	***Thembela plays with her hair. Anathi leans in and draws in breath and looks at the activity sheet***	Breath emphasis Posture		
	4		ANATHI	SPEECH	Wow!	Activity Exclamation		
12:47	5	2	DEBBIE	SPEECH	Have you seen one of these things before?	M question		Evaluating (1)
	6		ANATHI & THEMBELA	GAZE / SILENCE	***Debbie moves activity sheet on the table Both girls are silent but looking at the activity***			
	7		DEBBIE	SPEECH	Have you ever seen anything like this?	M question		Evaluating (1)
	8		ANATHI	GESTURE	***Points pencil at the activity***		L attention caught by m question (5 & 7)	
	9		THEMBELA	POSTURE	***Leans in closer but still playing with her hair***			
	10		DEBBIE	GESTURE	***Touches the activity sheet***			
12:51	11		ANATHI & THEMBELA	GAZE	***Girls are still silent but both looking at the activity sheet***			
12:55	12	3	DEBBIE	SPEECH	Okay. All right. Um ***[pause]*** Let me give you some ideas then.	M question		Setting the scene (1) Explaining (2a)
	13		DEBBIE	GESTURE	***Points to the totals on the chart***	M gesture		
	14		ANATHI & THEMBELA	GAZE / SILENCE	***Girls are still silent but both looking at the activity sheet. Thembela still playing with her hair***			
12:55	15		DEBBIE	SPEECH	Where … if you ... if you see something like this with a number at the end of the column or a number at the end of a row.	M question		
	16		DEBBIE	GESTURE	***Indicating rows and columns***			
13:02	17		THEMBELA	POSTURE	***Leans in closer to look at the chart***			
	18		DEBBIE	SPEECH	What do you think that number might mean?	M question		Probing (2b)
	19		THEMBELA	POSTURE	***Continues to look at the chart with hand on her cheek and then rests her chin on her pencil***			
13:10	20		ANATHI	POSTURE	***Leans forward and says something inaudible***			
13:11	21	4	ANATHI	GESTURE	***Anathi points to chart with her pencil***	L gesture		

[39] These numbers are a cross reference to the line to which the ACM refers

Time	Line Number	Turn	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
	22		ANATHI	EXPRESSION	***Anathi smiles at Debbie***			
	23		ANATHI	SPEECH	I think ***[speaking slowly]*** over here	L expressing something in direct response to M question (18)	L attention caught by question (18)	
13:12	24		ANATHI	GESTURE	***Indicating the chart***			
	25		DEBBIE	SPEECH	Okay… Anathi, carry on	M statement		Encouraging (1)
	26		DEBBIE	POSTURE / GESTURE	***Sitting back in her chair, gestures "continue" with her hand***			
	27		THEMBELA	GAZE	***Still looking at the chart***			
	28		ANATHI	EXPRESSION	***Covers her mouth with pencil and grins***			
	29		ANATHI	SPEECH	Yoh	Exclamation		
13:16	30	5	DEBBIE & ANATHI	POSTURE / GAZE	***Anathi sits back, still looking at the chart Debbie starts to say something but Anathi interrupts***			
	31		ANATHI	SPEECH	But … when you get to twenty over here it's like I'm counting in fives over here	L expressing something in direct response to M question (18)	L attention caught by question (18)	
	32		ANATHI	GESTURE	***pointing to the row of circles and the total 20***			
	33		DEBBIE	SPEECH	Okay carry on, explain.	M statement	M attention caught by learner expressing something (23 to 32)	Evaluating (1) Valuing (1) Seeking explanation (2b)
	34		DEBBIE	GESTURE	***Debbie indicates 'continue' with her hand***	M gesture		Rephrasing learner talk (2c) Making actions explicit (2c)
	35		DEBBIE	SPEECH	You're counting in fives. So count for me in fives.			
	36		DEBBIE	GESTURE	***Debbie points to each circle in turn whilst Anathi counts***	M gesture		
	37		ANATHI	SPEECH	Five, ten, fifteen, twenty.			
13:27	38	*6	DEBBIE	SPEECH	Okay so what are you saying here Anathi? That this, if we count it in fives here this would equal twenty. So this is the total, or it's the sum of the row?	M statement M question		Rephrasing learner talk (2c) Making actions explicit (2) Clarifying (2b)
	39		THEMBELA	EXPRESSION / GAZE / POSTURE	***Smiles slightly, still looking at the chart and sits up straight***			
	40		DEBBIE	GESTURE	***Debbie indicates various totals on the chart***			
	41		ANATHI	POSTURE / GAZE	***Sits up straight and folds her arms on the table, looking at the chart and Debbie's gestures***			
	42		ANATHI	GESTURE	***Rubs her eye***			
	43		THEMBELA	GESTURE	***Plays with her hair again***			

Description of what is happening in this event

This event is the beginning of task 3 in the task-based interview. As mentor I set the scene for the task as neither learner has seen a puzzle like this before. I use evaluating questions to see if Anathi and Thembela can work out what the numbers at the end of the rows and columns might mean.

By turn 4 (lines 21 to 24), Anathi has worked out the value of a circle (33 seconds from the start of the task). In turns 5 to 7, I respond to what Anathi expressed and rephrase her contribution to ensure that I understand what Anathi is saying. In turn 7, I build on what Anathi said to clarify what the other totals on the chart would then mean.

The *verbal* interactions are mostly between Anathi and myself. Thembela does not initially seem to be engaged with the task and plays with her hair (lines 3 and 14) although she looks at the activity. However, in line 17 she leans in closer to look at the activity and continues to look at it whilst Anathi and myself interact. In line 39 Thembela smiles and sits up straight when I point to something on the chart, which indicates that perhaps she had been following the conversation.

Attention Catching and Mediation

Thembela initially plays with her hair and only contributes to interactions in line 17. On the other hand, Anathi’s attention is immediately caught by the task; she leans in to look and draws in her breath, indicating that she is becoming engaged by the task. The event illustrates how Anathi contributes a possible answer (line 31) and is then encouraged to verbalise her thinking through mediation which then leads to catching Thembela’s attention as indicated by her expression and posture (line 39). Thembela is however, not engaged and does not enter the discussion verbally. My revoicing or rephrasing of Anathi’s thinking / contributions (line 38) seems to catch Thembela’s attention for a small while.

When Anathi expresses herself (lines 31 and 32) my attention is caught and I immediately use *reviewing* (level 2b) and *restructuring* (level 2c) practices. Additionally, in turns 2 and 3, I set the scene by orientating the girls towards this type of task. Anathi’s actions and talk seem to be modified by this as indicated by her pointing her pencil at the chart a couple of times, leaning forward, smiling, grinning and use of other expressions (lines 8, 20, 21, 22, 24, 28). The mediation is low-key as indicated by a little probing and setting the scene, apart from when I ask Anathi to explain her thinking (turn 5). I then rephrase, make her actions explicit and clarify her understanding. These mediating practices perhaps are what draw Thembela into the task at the end of the critical event.

Critical event 2: Sustained task engagement and further attention catching

I chose this second event to illustrate how mediation provided by myself as the mentor helps the girls make their way through many unsuccessful trials for finding values of the triangle and club.

What has happened since the last transcript?

The transcript of lines 44 to 167 is available in Appendix I. In lines 50 to 88, Thembela joins the conversation by offering an answer to a question and I explain that each shape will have a different number. I then ask Anathi to verbalise the thought that she had about the circles. After Anathi has explained, I seek agreement from Thembela and encourage the girls to write the proposed value of the circle ("5") on paper.

In lines 99 to 108 I then refocus the girls and orient them towards the next steps. "Now you've got to work on what the triangle is" and "what the tree is". I also invite them to collaborate (lines 99 to 112).

My attention is caught when Anathi says something (line 117). I ask her to verbalise her thinking and Anathi responds directly to the request. I then rephrase what she has said (lines 122 to 126) and connect what she said to something that happened in a previous club session which catches the girls' attention (lines 127 to 133). They agree that the clubs need to be lower than 10 (lines 135 to 141). Thembela then offers an idea for the triangle (line 146) and I ask her to test whether her idea will work (line 146). Thembela checks and finds that it doesn't (line 152). I respond by re-iterating that each shape is a different number. After some thinking and discussion, the girls state that the clubs are equal to 4 (lines 164 to 167) and this is recorded on Thembela's paper.

The transcript for this critical event begins at line 168.

Time	Line Number	Turn	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
	168	*19	DEBBIE	SPEECH	Okay, test it. Oh, how can you test it though?	M statement / question		Seeking justification (2b) Probing (2b)
	169		THEMBELA	SPEECH	I said four plus five is nine, four…..	L expressing something		
	170		THEMBELA	GAZE	***Looks at Debbie***			
	171		DEBBIE	SPEECH	Okay, so you're saying four and four is eight and five is..?	M question		Making talk explicit (2b)
	172		ANATHI	ACTION	***Anathi meanwhile is writing something on her paper***			
	173		THEMBELA	SPEECH	Oh, wait, I said 4 and 4 is 8, right then plus a 5 is 21	L expressing something in direct response to M question (171)	L attention caught by question (171)	
17:35	174		DEBBIE	SPEECH	Is it? 8 plus 5..?	M question		Prompting (2b)

Time	Line Number	Turn	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
	175		THEMBELA	GAZE / EXPRESSION	***Looks at Debbie and sighs***			
	176		ANATHI	GAZE / EXPRESSION	***Anathi repeats the sum and looks at Debbie with a quizzical look***	Eye contact L->M	L attention caught by question (174)	
	177		THEMBELA	EXPRESSION	***Thembela gives a big sigh***			
	178		ANATHI	SPEECH	13	L statement		
	179		THEMBELA	POSTURE	***Thembela lifts both hands above her head and makes an inaudible contribution***	Posture		
17:42	180		DEBBIE	SPEECH	So what would this be then? So you're saying the triangle maybe is………?	M question	M attention caught by posture (179)	Probing (2b) Making talk explicit (2b)
	181		ANATHI & THEMBELA	SPEECH	Eleven	L statement		
	182		DEBBIE	ACTION	***Debbie records "11" on the scrap paper***			
	183		THEMBELA	GAZE / EXPRESSION	***Looking at the chart and making a grimace***			
	184		DEBBIE	SPEECH	Okay how can we test it? Because we've got some triangles here. Will that work?	M question		Seeking justification (2b)
	185	20	THEMBELA	POSTURE / GESTURE	***Sits on edge of her chair and straightens her posture, covers all but the final column of the chart with her hand***			
	186		THEMBELA	SPEECH	Wooa. Wooa	L statement	L attention caught by question (184)	
	187		ANATHI	POSTURE / GESTURE	***Anathi leans back in her chair & covers her mouth with her hand***			
	188		THEMBELA	SPEECH	5 plus 11	L expressing something in direct response to M question (184)		
	189		THEMBELA	POSTURE / GAZE	***Leans back in her chair, looking at Thembela's gestures***			
	190		ANATHI & THEMBELA	SPEECH	16 ***[in unison]***			
	191		THEMBELA	SPEECH	plus another 5…			
	192		THEMBELA	GAZE	***Looks at Anathi***	Eye contact L->L		
	193		ANATHI	SPEECH	21	L expressing something in direct response to M question (184)		
18:12	194		THEMBELA	SPEECH	plus another 11…. no it's not			
	195		THEMBELA	EXPRESSION / GAZE	***Thembela shakes her head emphatically and looks at Debbie, alters position in chair and leans over the table***	Expression Eye contact L->M Posture		
	196		ANATHI	EXPRESSION	***Anathi frowns***	Expression		
	197	21	DEBBIE	SPEECH	Okay so the triangle can't be 11. So that one's not gonna work. All right.	M statement	M attention caught by eye contact, posture, expression	Making talk explicit (2b) Encouraging (1)

Time	Line Number	Turn	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
							(195)	
	198		DEBBIE	ACTION	***Debbie scratches out the "11" on the scrap paper***	M action		
	199		ANATHI	POSTURE / GAZE	***Crosses her arms and looks at the chart***			
	200		THEMBELA	GAZE	***Continues to look at the chart***			
	201		THEMBELA	SPEECH	It can't be 11. 5, 10.	L expressing something		
	202		DEBBIE	SPEECH	10? Okay, good. I like that. What is the total here?	M question	M attention caught by learner expressing something (201)	Encouraging (1) Valuing (1) Prompting (2b)
	203	*22	DEBBIE	GESTURE	***Debbie indicates the total for the 4th column on the chart***	M gesture		
	204		ANATHI & THEMBELA	GAZE	***Girls look at the chart***			
	205		ANATHI & THEMBELA	SPEECH	26 ***[in unison]***	L statement	L attention caught by question, gesture (202-203)	

Description of what is happening in this event

I ask Thembela to test the idea that the club might be 4 (line 168). Thembela adds 4, 4 and 5 and gets 21 (lines 169 to 173). I prompt her to check and Thembela sighs twice (lines 175 and 177). Anathi gives an answer of 13 (line 178). Thembela's posture suggests frustration. This catches my attention, and I try to rephrase what they have said (to make their talk explicit in line 180) through recording on paper that the triangle may be 11. I go on to seek justification from the girls that this will work (line 184). Thembela sits up straight and points to the chart. In lines 185 to 194, the girls work out that the 11 doesn't work for the triangle. Thembela shakes her head and looks at me (line 195) and Anathi frowns (line 196).

My attention is once again caught by their postural and expression interactions, so I encourage them and made their talk explicit (line 197). In line 201, Thembela says "It can't be 11. 5, 10…" which catches my attention. I prompt the girls to look at the total for column 4 (line 202) and they both respond directly to my question (line 205) reading and saying "26" in unison.

Attention Catching and Mediation

The transcript shows that this may be a frustrating time for Anathi and Thembela as they are not experiencing much progress. Attention is caught for both learners and myself in various ways. I make use of questions as a way of keeping the girls focussed and in an attempt to help them move forward. There are two instances where my attention is caught by the girls expressing themselves verbally and I follow this up with mediation aimed to encourage them, value their contributions so far and rephrase what they have said.

Critical event 3: Mediation as attention catching mechanisms

This final event for this episode was chosen to show how my mediation catches Anathi's attention and assists her to benefit from the mediation I offer by verbalising what she did mentally and reflecting on these mental actions.

What has happened since the last event

The girls focus their attention on the 4th column of the puzzle; Thembela covers all the other columns with her hand. I encourage them to continue trying other numbers for the triangles (line 221). In line 227, I catch the girls' attention when I say "you've got ten and are trying to get to?" This foregrounds the need for both triangles to add to 16 and Anathi responds with "aaah, I know, the triangles are 8" (line 229). I ask her to verbalise her thinking and she goes on to do so (lines 234 to 248) with encouragement from me. Thembela is listening and joins in with answers to calculations as Anathi explains. I seek Thembela's agreement and she says "Yeeeees" and laughs loudly as if in relief. I direct them to record what the triangle is and ask them to justify that it will work (lines 252 to 263).

Thembela now calculates 5 + 8 = 13 and is looking at the second row. I ask them what they are trying to get to (i.e. 25, the total for the 2nd row). Anathi is interested in what the value of the 'flies' might be. There is then some discussion about the 'flies' (clubs) and Thembela expresses that 2 'flies' would be double "that" (line 281). I attempt to reach a consensus of where they are in their thinking and problem solving. That is: "the circles are always 5. The triangles you say are 8. So, you've got to find out if these are going to be the same number" (line 286). Both girls continue to look at the chart, exclaiming and laughing as they try different numbers.

This critical event starts at transcript line 297.

Time	Line Number	Turn	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice (level)
20:58	297	37*	ANATHI	SPEECH	Eish, hey hey. You see what I did?	Exclamation L expressing something		
	298		ANATHI	GAZE	***Looking at Debbie whilst she talks***	Eye contact L->M		
	299		THEMBELA	GAZE / EXPRESSION	***Looking at the paper and smiling softly***			
	300		ANATHI	SPEECH	I went like … I went … 13	L expressing something	L attention caught by exclamation, l expressing something, eye contact (297-298)	
	301		ANATHI	GESTURE	***tapping the circle and triangle on the 2nd row of the chart***	L gesture		
	302		ANATHI	SPEECH	and then I went 13,	L expressing something		
	303		ANATHI	ACTION	***starts counting on fingers***			
	304		ANATHI	SPEECH	14, 15, 16, 17, 18,19, 20, 21, 22, 23, 24, 25.	L expressing something		
	305		THEMBELA	POSTURE / GAZE	***Sitting back in her chair, with hand on her shoulder. When Anathi says 25, she looks at Debbie***			
21:14	306		ANATHI	SPEECH	Aaah! ***(in excited tone)***	Exclamation		
	307		ANATHI	POSTURE	***Anathi looks at Debbie, throws back her arms and leans back in her chair***	Posture Eye contact L->M		
	308	38	DEBBIE	SPEECH	What's the difference? What is the difference there?	M question	M attention caught by exclamation, posture, eye contact (306-307)	Introducing mathematical language (2c) Making actions explicit (2b)
	309		ANATHI	GAZE	***Looks at the chart, pauses as if thinking***			
	310		DEBBIE	GESTURE	***Debbie gestures with her pencil to Anathi***	M gesture		
	311		ANATHI	GESTURE / GAZE	***Anathi covers her mouth with her hand, then continues to look at Debbie***	L gesture		
	312	39	DEBBIE	SPEECH	What did you count up there? You counted it up. What is the difference between thirteen and twenty five? Was?	M question		Probing (2b) Introducing mathematical language (2c)
	313		THEMBELA	POSTURE / GAZE	***Still sitting back in her chair, brief eye contact with Debbie***			
	314		ANATHI	POSTURE / ACTION	***Anathi sits forward in her chair again, looks at Debbie, wipes her face with her hands***	Eye contact L->M		
	315		THEMBELA	GAZE	***Thembela looks at Anathi***	Eye contact L->L		
	316		THEMBELA	POSTURE	***Thembela closes her eyes as if thinking***			
	317		DEBBIE	SPEECH	Do it again for me. You did 13 …	M statement		Making actions explicit (2b)
	318		ANATHI & DEBBIE	ACTION	***Anathi counts on her fingers and Debbie silently mimics her action***	L action	L attention caught by statement (317)	

Time	Line Number	Turn	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice (level)
	319		ANATHI	SPEECH	13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25 … Ooooh	L expressing something		
	320		ANATHI	POSTURE / GAZE	***Anathi flings hands up again and looks at Debbie***	Posture Eye contact L->M		
	321		ANATHI	SPEECH	Yoh, 6	Exclamation		
	322		DEBBIE	SPEECH	Was?	M question	M attention caught by posture, by exclamation and by expressing something (319-321)	Prompting (2b)
	323		ANATHI	SPEECH	12	L statement		
	324		DEBBIE	SPEECH	Okay so she counted up 12 to get to what?	M question		Making actions explicit (2b) Introducing mathematical language (2c)
21:36	325	40	ANATHI	POSTURE	***Anathi pulls chair up to the table***	Posture	L attention caught by question (324)	
	326		THEMBELA	POSTURE	***Thembela sits back in chair, nods***	Posture		
	327		ANATHI & THEMBELA	SPEECH	25	L statement		
	328		ANATHI	ACTION / GAZE	***Anathi starts writing on her paper and looks at Debbie***	L action Eye contact L->M		
	329		DEBBIE	SPEECH	Okay, now so what do you think the club is?	M question	M attention caught by statement, action, eye contact (327-328)	Probing (2b)
	330	41	THEMBELA	GESTURE / ACTION / POSTURE	***Shakes her pencil and starts writing on her paper, leaning back into the table***			
	331		ANATHI & THEMBELA	SPEECH	6 ***[Thembela joins in]*** the club is 6	L statement	L attention caught by question (329)	
	332		ANATHI	GAZE	***Continues to look at Debbie***	Eye contact L->M		
	333		THEMBELA	ACTION	***Thembela writes on paper: "club=6"***	L action		
	334		DEBBIE	SPEECH	Why?	M question		Seeking justification (2b)
	335		ANATHI	SPEECH	Ooooh…	Exclamation	L attention caught by question (334)	
21:39	336	42	ANATHI	POSTURE / GESTURE	***Anathi claps her hands, does a little dance in the chair, leans back into the table and taps the chart with her pencil***	Posture		
	337		ANATHI	SPEECH	because half of the twelve is 6	L expressing something in direct response to m question		

Time	Line Number	Turn	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice (level)
						(334)		
	338		ANATHI	GESTURE	***Tapping the chart with her pencil***			
	339		ANATHI	POSTURE / GESTURE	***Anathi sits back in her chair, makes an expansive hand gesture and looks at Debbie***	L gesture / posture Eye contact L->M		
21:44	340	43	DEBBIE	SPEECH	Aaaah. ***[rising intonation]*** Okay, alright so we're saying this is a...?	M question	M attention caught by gesture, posture and by expressing something (337 & 339)	Establishing joint understanding (2c)
	341		DEBBIE / ANATHI & THEMBELA		6	L statement		
	342		THEMBELA	GAZE	***Thembela looks at Debbie***	Eye contact L->M		
	343		DEBBIE	GESTURE	***Debbie points to the club on Thembela's paper***	M gesture		Using symbols (3)
	344	44	DEBBIE	SPEECH	Let's try it. Let's add up another one and see if…	M statement		Seeking justification (2b)
	345		DEBBIE	GESTURE	***indicates another row on the chart***			
	346		THEMBELA	SPEECH	Ok	L statement		
22:01	347	*45	ANATHI	ACTION	***Anathi looks at her workings***			
	348		DEBBIE	SPEECH	Just do either one column or one row. You can choose which one	M statement		Directing (2a)
	349		ANATHI	SPEECH	Let's start with this one.	L statement	L attention caught by statement / gesture (343-344)	
	350		ANATHI	GESTURE	***Anathi points to final row of the grid and checks the symbols values written on her scrap paper (see*** Figure 30 ***below)***	L gesture		
	351		ANATHI	SPEECH	16, 17, 18 … 16 plus..			
	352		THEMBELA	SPEECH	16 plus 12 ….	L expressing something	L attention caught by statement / gesture (349-350)	
	353		ANATHI	SPEECH	28. I think so.	L expressing something		
	354		ANATHI	GAZE / POSTURE	***Anathi looks briefly at Debbie, with her arms crossed***	Eye contact L->M		

Description of what is happening in this event

The mediation in the lines before this event catches the learners' attention and leads to Anathi expressing something "Eish, hey hey. You see what I did?" She then explains what she did (lines 298 to 307). My attention is caught by her question and explanation and leads me to introduce the mathematical language of "difference". I also make Anathi's actions explicit by asking a question (line 308). Anathi doesn't respond as she seems to be thinking. I probe further using mathematical language of "the difference between" (line 312). Anathi sits forward, makes eye contact with me but still does not respond. Thembela looks at Anathi (lines 313 to 316). I ask Anathi to do her counting again (line 317). Anathi does it and then goes "Ooooh" (line 319). She flings up her hands and says "Yoh, 6".

My attention is caught by Anathi's exclamation and I prompt her (line 322). I then make Anathi's actions explicit by rephrasing in mathematical language: "Okay so she counted up 12 to get to what? " (line 324). Anathi's attention is caught, Thembela nods and they both say "25". I probe, asking what the club is (line 329). Both girls say "6, the club is 6" (line 331). I ask for justification ("why"), which captures Anathi's attention. She dances, claps her hands and in direct response to my question as she explains "because half of the twelve is 6", making an expansive hand gesture as she does so (lines 337 to 339). I attempt to arrive at consensus (line 340) and then go on to seek justification that this value of 6 will work in another place. Anathi chooses a place (line 349) and they work it out.

Attention Catching and Mediation

This event illustrates how the combination of *speech*, *body postures* and *exclamations* (especially by Anathi) attracts the attention of myself as the mentor as well as portraying a sense of excitement in Anathi as she works through her thinking. By gaining my attention in this way, I am drawn in to mediate at each of these points with brief encouraging comments but without throwing the learner off her thought processes. The attention catching mechanisms used by myself continue to be *speech* based and relate directly to level 2b and c mediation practices. In other words, almost every statement or question utterance I make is a form of mediation. This mediation in turn acts as an ACM.

I use *reviewing* (level 2b) and *restructuring* (level 2c) practices in this event. The reviewing practices aim to help Anathi clarify her thinking (lines 308, 312, 317, 322, 324, 329, 334 and 344) and reflect on what she did. The restructuring practices are about progressively making ideas accessible to both girls and about moving them forward in their understanding (lines 308, 312, 324 and 340). As in the second event, the use of symbols reinforces the usefulness of representational tools for thinking (line 343) shown in Figure 30.

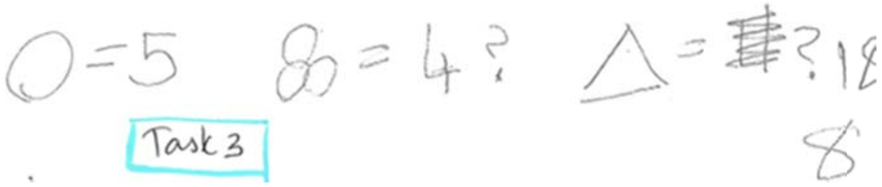


Figure 30: Using symbols as tools for thinking (Episode One)

Key insights from these three critical events

My articulated notion of the ZPD indicates that a ZPD as a symbolic space, does not exist prior to the learning activity and is created (or not) through the social interactions with others during club activities. The emergence of the ZPD depends on the active contributions of the learners as well as the mentor.

Much of the interaction in this episode is between myself and one learner at a time. There is not much interaction between the learners themselves and they seem to act separately from each other although their speech and writing catches the other's attention. Thus there is evidence of them listening to each other (catching each other's thoughts) which seems to keep both of them interested in completing the task. See for example, lines 173, 178, 185 to 196 and 324 to 328.

I argue that a ZPD is created for Anathi from the beginning of placing the task in front of here where her attention is caught by the activity itself. This is evident from her posture (leaning forward, intake of breath), gaze, exclamation ("wow") and her mathematical contribution within a short space of time (33 seconds). In the three critical events shown, it seems as if Anathi solves all of the clues in the puzzle. It is clear that Anathi is able to progress in collaboration with myself and that her contributions (including non verbal, non mathematical interactions) actively co-construct the ZPD. In other words I do not create the ZPD for her, rather it is co-created by her direct contributions and how I respond to those contributions as she makes them.

This may not be the case for Thembela who didn't immediately actively engage with the task, choosing rather to be an observer. Once ideas and possible solutions were verbalised, Thembela agrees and seems to understand how Anathi got the solutions but she is not seen to contribute suggestions herself. Even though Thembela contributes equally in the episode from an interactional point of view as to her number of *speech* turns (Table 48), it is not clear if these interactions are moving her towards a way to solve the puzzle. For these reasons, I would suggest that Thembela is operating on the periphery of Anathi's ZPD in this episode. However, even if this is the case, perhaps this activity serves a consolidating function for Thembela in terms of her learning. In a learning process there cannot constantly be challenge and new leaning. Sometimes consolidation and opportunities to practice are needed to strengthen learner fluency. Learners also require the opportunity to build confidence in being able to use, apply and communicate what they already know. This seems to be the case with Thembela. I discuss this idea further in the closing section of this chapter.

Siemon and Virgona (2003) state that every mediating practice has a different level of teacher support and learner independence, therefore not all interactions have the same value or quality. The set of actions I invoke in this episode are those that encourage the learners to reflect on and clarify their contributions. Even though I used the same mediation for both learners, I suggest that the mediation was more effective for Anathi. However, it was possible that Thembela perhaps required more direct mediation in order for her own thinking to move forward. As it stands she may have developed understanding by catching Anathi's thoughts.

For the whole episode, the mediation I provide is mostly focused at the reviewing type practices (level 2b). Table 55 indicated that I used a wide range of reviewing practices that allowed the learners to develop their understandings and clarify and reflect and as such enabled me to act as a co-constructor of the ZPD. Examples of these practices are: seeking justification, prompting, probing, making talk and action explicit and clarifying.

End of critical events for Episode One

EPISODE TWO: NATE & ZAC (BOYS) AT ELMTREE PREP

The highlights from the broad analyses of this episode in the earlier section lead me to present three critical events for Episode Two. As analytical discussions these were chosen to exemplify the following:

1. Attention caught by the task and success in solving part of the problem
   Turns 6 to 9 (1 minute 40 seconds from start of task, lines 56 to 79)
2. *Using attention catching mechanisms to keep learners focussed on the activity*
   Turns 28 to 31 (3 minutes into the task, line 192 to 233)
3. *Learners catch each others' attention and mentor awareness of learner contributions*
   Turns 35 to 39 (approximately 7 minutes into the task, lines 261 to 286)

Introduction to the critical events for Episode Two

As with the girls' in episode one, the boys (Nate and Zac) have completed Tasks 1 and 2 in the interview and have just been introduced to Task 3 by Mellony who is facilitating. The boys say they have not seen an activity of this kind before so Mellony explains the symbols and totals and what the boys have to solve. Nate states at the start the it will be hard. However, with minimal mediation from Mellony they solve the first part of the task in approximately 47 seconds. In total it takes them 8 minutes and 23 seconds to solve the entire puzzle.

Note: in this episode, Mellony and the boys also referred to the club shape as a "clover".

Critical event 1: Attention caught by the task and success in solving part of the problem

This event was selected to illustrate how the task catches the boy's attention and how success in solving part of the problem motivates them to continue. Mellony as facilitator has spent about a minute and a half introducing the activity to the boys. She has explained what the totals and shapes represent and has invited the boys to work together: "And you're welcome to discuss, you can do this one together alright?" (line 54). This excerpt begins at line 56.

Time	Line number	Turn	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
35:06	56	*6	NATE	SPEECH	This is going to be hard	L expressing something		
	57		MELLONY	EXPRESSION	***Mellony laughs***		M attention caught by learner expressing something (56[40])	
	58		NATE & ZAC	POSTURE	***Both boys lean in to the table***			
	59		NATE & ZAC	GESTURE / ACTION	***Zac and Nate point their pencils to the 2nd row on the chart and begin to work on the task, in whispers***			
35:11	60		NATE	GAZE	***Looks at Zac***			
35:13	61		DEBBIE		***Asks the boys to speak louder for the video***			
35:19	62	7	ZAC	SPEECH	***[Speaking slowly]*** So this will be 10 and 10 that will be 20. This will be 3 and 2	L expressing something		
	63		NATE	GAZE	***Nate looks at Zac***	Eye contact L->L		
	64		ZAC	GAZE / GESTURE	***Zac looks at Nate points to the 3rd row of the chart (the circles) and explains***	Eye contact L->L	L attention caught by eye contact and by learner expressing something (62-65)	
	65		ZAC	SPEECH	This will work out … 5, 10, 15, 20	L expressing something		
	66		ZAC	GESTURE / GAZE	***Zac counts backwards along the row of circles, still making eye contact with Nate***			
	67		NATE	SPEECH	Oooh ***(tone of realisation)***	L expressing something in direct response to other learner expressing something (65)	L attention caught by expressing something (65)	
	68		NATE	EXPRESSION / GESTURE	***Nate laughs and covers his head with his hand***			

[40] These numbers are a cross reference to the line to which the ACM refers

Time	Line number	Turn	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
35:28	69		ZAC	EXPRESSION / GAZE	***Short laugh and glance at Nate***			
	70		MELLONY	SPEECH	Okay, so why are you saying 5, 10, 15, 20?	M question	M attention caught by learner expressing something and by interaction (62-69)	Probing (2b)
35:36	71	8	ZAC	SPEECH	***[inaudible]*** Because…			
	72		ZAC	GAZE	***Zac looks at Mellony***	Eye contact L->M		
	73		ZAC	SPEECH	this is gonna have to be 5	L expressing something in direct response to m question (70)		
35:43	74		MELLONY	SPEECH	Okay, cool, so you've already figured out that the circle equals?	M question	M attention caught by learner expressing something and by eye contact (72-73)	Valuing (1) Evaluating (1) Making actions explicit (2b)
	75		MELLONY	ACTION	***Mellony picks up her pencil, draws a circle on scrap paper and Zac writes a number***	M action		Using symbols (3)
	76	*9	NATE	GAZE	***Nate continues to look at the chart***			
35:47	77		ZAC	SPEECH	5	L expressing something in direct response to m question and action (74-75)	L attention caught by action (75)	
	78			ACTION	***Writes "5" next to the circle***			
34:45	79		NATE	GAZE / GESTURE	***Continues looking at the chart and pointing to shapes***			

Description of what is happening in this event

Nate immediately indicates that the task is going to be hard (line 56) but both boys engage with the task within a space of 13 seconds. Both boys start work on the 3rd row of circles in the puzzle but then Zac captures Nate's attention by looking at him and making eye contact (line 64) thus initiating learner-learner communication. He explains that the circles could be 5 each and as a result modifies Nate's action and utterance (line 67). Mellony's attention is captured by this learner-learner interaction and she mediates by *probing* in order to *clarify* their thinking (line 70: "Why are you saying 5, 10, 15, 20?").

Eye contact is then established between Zac and Mellony (line 72) as he explains his thinking to her. She subsequently captures the boys attention by making their *actions explicit* “you have figured out what the circle equals” (line 74) and by drawing a circle *symbol* on scrap paper so that Zac can write their solution of 5 next to it. The mediational actions in this event are mainly at those of *reviewing* and clarification of understanding (level 2b) but Mellony’s use of symbols as a *representation tool* for notating thinking is noteworthy because it is a level 3 practice according to Anghileri’s model, indicating that the quality of the mediation is deeper by providing an extended range of interactions to the learners. Furthermore, using symbols is a theme that runs through the longer episode of which this event is a part.

Attention Catching and Mediation

Speech-based interactions in this event are minimal. Mellony invites the boys to collaborate, clarifies their thinking and draws their attention to their solution. More importantly, she begins to develop the boys’ symbolic workings by using the drawing of symbols on paper as a tool for notating their thinking. What is seen though is that the boys readily engage with the task and even though Nate indicates it may be hard at the outset. They solve the first clue within approximately 47 seconds.

Various actions and statements catch the attention of both the learners and Mellony. When Mellony’s attention is caught, she makes an “in-the-moment micro-decision” (Watson, 2007, p. 118) and provides mediation. The level of independence shown by boys themselves seems relatively high but both the catching of thoughts and mediation seems to help them clarify their understanding, move forward with solving the puzzle as well as assisting in recording their workings.

Critical event 2: Using attention catching mechanisms to keep learners focussed on the activity

I chose this second event to show how Mellony re-captures Nate’s attention using both mediation and other non-verbal ACMs to keep him focussed on the activity.

What has happened since the last event

Three minutes on the boys are still working at finding the values for the triangle and the club. They have both been working on different aspects of the puzzle and have offered a number of different values for these shapes, which they have been encouraged to test by Mellony (lines 130 and 132 in Appendix I) and have found not to work. In the seconds before this event, they have focussed their attention on finding the value of the triangles in the final column of the puzzle. This critical event picks up the transcript at line 192.

Time	Line Number	Turn	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
38:41	192	28	NATE	SPEECH	Hey!	Exclamation	L attention caught by m statement (189 & 191)	
	193		NATE	SPEECH / GESTURE	***[whispers to Zac and pokes him with his pencil]*** 8	L statement		
	194		MELLONY	GESTURE / SPEECH	***Mel touches Nate's shoulder with her finger*** Ok, come	M touch / statement		Encouraging (1)
	195		NATE	INTONATION	***Then he says more loudly***	Learner expressing something in direct response to touch	L attention caught by m touch (194)	
	196		NATE	SPEECH	it's 8!			
	197		NATE	POSTURE	***Nate leans back***	Body movement		
38:44	198		MELLONY	SPEECH / INTONATION	Ja. Ja ***[rising intonation]*** How did you get that?	M statement	M attention caught by learner expressing something (196)	Encouraging (1)
	199		NATE	POSTURE	***Nate leans back in and looks at Zac***	Body movement		
	200		NATE	SPEECH	8 and 8 ***[with Zac]*** is 16	Learner expressing something	L attention caught by m statement (198)	
			ZAC		***[joins in]*** is 16			
	201		ZAC	SPEECH	16 plus 10, is 26	Learner expressing something		
	202		NATE	GAZE & EXPRESSION	***Nate looks at Zac and smiles***	Eye contact L->L		
	203		ZAC	GESTURE / GAZE	***Plays with the neck of his jacket and looks down at the table***			
38:52	204		MELLONY	SPEECH	Woo hoo	Exclamation	M attention caught by learner expressing something (200-201)	Encouraging (1)
	205	29	DEBBIE	SPEECH	How did you get that Nate?	M question		Making thinking explicit (2b)
	206		NATE	EXPRESSION & GAZE	***Nate smiles and looks directly at Debbie***	Eye contact L->M	L attention caught by m question (205)	
	207		ZAC	GAZE / POSTURE	***Looks at Nate, shifts in his chair and leans on the table***			
39:00	208		NATE	SPEECH	Well, I was counting, so what equals… so 10, 18 plus what equals 26? And I just counted on … in 8s …	L expressing something		
	209		NATE	GESTURE	***Points to the shapes in column 4 whilst explaining***			

Time	Line Number	Turn	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
	210		ZAC	ACTION	***Zac listens and appears to be checking the numbers himself as he points to the shapes in column 4***			
	211		NATE	GAZE	***Nate looks at Zac***	Eye contact L->L		
	212		MELLONY	SPEECH	Because 8 and 8 is …?	M question		Prompting (2b)
	213		MELLONY	GESTURE	***Mellony points to Nate***	M gesture		
	214		NATE	GAZE	***Looks at Mellony making eye contact***	Eye contact L->M		
	215		NATE	SPEECH	***[pauses whilst thinking]*** 16	L expressing something in direct response to question (212)	L attention caught by m question (212)	
	216	30	MELLONY	SPEECH	Well done. Okay. All right, so it was 16 plus the 10, is 26. Am I right?	M statement M question		Encouraging (1) Promoting joint understanding (2c)
	217	30	NATE	GAZE	***Looks briefly at Zac***			
	218	30	ZAC	GAZE	***Looking at the activity***			
	219	30	MELLONY	SPEECH	All right, so it was 16 plus the 10, is 26. Am I right?	M statement M question		Encouraging (1) Promoting joint understanding (2c)
	220	30	NATE	SPEECH	Hmm ***[in agreement]***			
	221	30	NATE	EXPRESSION	***Slight nod of his head***			
	222	31	MELLONY	SPEECH	Okay, so well done. So now you are pretty convinced	M statement		Encouraging (1) Promoting joint understanding (2c)
	223	31	MELLONY	GESTURE	***Mellony points to paper with notes***			Using symbols (3)
	224	31	MELLONY	SPEECH	Revise this, you can do it one piece of paper. Well done Nate	M statement		Directing (2a) Encouraging (1)
	225	31	ZAC	ACTION	***Changes the values on the paper, although the video does not show what he writes***	L action		
	226	31	MELLONY	GESTURE	***Mellony pats Nate on the shoulder***	Touch		
	227	31	MELLONY	SPEECH	He figured out this one is 8	M statement		Making talk / actions explicit (2b)
	228	31	MELLONY	GESTURE	***Pointing to the triangle on scrap paper***			
	229	31	MELLONY	SPEECH	Now as you said …	M statement		Making talk / actions explicit (2b)
	230	31	MELLONY	GESTURE	***Mellony points directly to Zac***			
	231	31	ZAC	GAZE	***Looks briefly at Mellony***			
	232	31	MELLONY	SPEECH	… the clover has also got to be wrong because if you've now changed the triangle, so let's see.	M statement		
39:40	233	31	NATE & ZAC	GAZE / EXPRESSION / POSTURE	***Boys look at each other and giggle***	Eye contact L->L Body movement	L attention caught by m statement (229 & 232)	

Description of what is happening in this event

In line 192, Nate makes an exclamation, “Hey!”. Nate whispers a value, which Zac does not hear. Mellony encourages Nate to continue by touching him on the shoulder and he repeats his value louder (“Its’ 8!”) and leans back in his chair (line 196). This time Mellony encourages him verbally (“Ja. Ja”) and Nate makes eye contact with Zac (line 199). Both say “8 and 8 is 16” (line 200) at the same time. Mellony makes an encouraging celebratory utterance “woo hoo” and I (recording the video) ask Nate to make his thinking explicit (line 205). Eye contact is established between Nate and myself as he explains. Zac listens and Nate’s explanation captures Zac’s attention (lines 208 to 215). Zac checks Nate’s reasoning. Mellony uses a pointing gesture to get Nate’s attention and mediates by prompting him to clarify his thinking (lines 212). In lines 216 to 228, Mellony encourages the boys to clarify their thinking and progress, achieves consensus about what they have just done and urges the boys to again record the symbols and values on the paper. She then encourages the boys to now pay attention to the club (clover) in line 232.

Attention Catching and Mediation

In this event, there is a balance between learner and mentor attention being caught. Of note is that there are two instances where learners express themselves, which catches Mellony’s attention and she follows up with mediation. Lines 216 to 232 show frequent mediation but rather than attention being caught here, I characterise this as a period of consolidation and reflection before moving onto solving the next clue. Mellony encourages, ensures joint understanding between the two boys and makes certain learner contributions explicit.

As a result, instances of coded mediation in this critical event are higher than in the previous event and the mediation practices used are those of *encouragement*. *Reviewing* type (level 2b) mediation practices are used to clarify the boys’ understanding and to encourage reflection on their contributions and could be seen to be developing a richness (or quality) in the mathematical interactions taking place between the participants. *Restructuring* (level 2c) practices are also evident and are used to restructure the boys’ thinking in terms of *promoting joint understanding*. The practice of *using of symbols* as a representational tool is re-enforced.

Critical event 3: Learners catch each others' attention and mentor awareness of learner contributions

This final event for the boys was selected to illustrate how attention catching can occur between learners and how the mentor's awareness of what they contribute leads to mediation.

What has happened since the last event

At this point in the task (40:39), the boys have found values for each shape and Zac has written these values on a piece of scrap paper. They are now ready to prove that the values work in all scenarios before completing the task. The critical event continues at line 261.

Time	Line Number	Turn	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
40:39	261	35	MELLONY	SPEECH	Okay, double check. Convince me. Show me.	M statement		Seeking justification (2b) Promoting joint understanding (2c)
	262		NATE & ZAC	GAZE	***Both boys look at the activity***			
	263		ZAC	SPEECH / GESTURE	***[pointing to the clubs in row 2]*** If it's 6, plus another 6,	Learner expressing something		
			NATE & ZAC	SPEECH	[***Nate joins in and they say in unison]*** is 12 plus 5 is 17			
			ZAC		plus 8			
			NATE & ZAC		***[Nate joins in and they say in unison]*** is 25			
	264		NATE	EXPRESSION / GAZE	***Grins and looks at Zac***	Eye contact L->L		
	265		ZAC	GAZE	***Looks up and makes brief eye contact with Mellony***	Eye contact L->M		
	266	36	MELLONY	SPEECH	Cool. I'm convinced. Now convince me this way	M statement	M attention caught by learner expressing something (263)	Seeking justification (2b) Promoting joint understanding (2c)
	267		MELLONY	GESTURE	***Mellony points to another column on the activity sheet***			Directing (2a)
	268	37	ZAC	SPEECH	10	Learner expressing something		
			NATE	GESTURE / SPEECH	***[whilst pointing to column 4, echoes]*** 10			
			ZAC	SPEECH	yoh, 5, 5, 10			
			NATE		***[echoes]*** 10 plus 8, plus 8 …			
			ZAC		is 16			
			NATE		is 26			

Time	Line Number	Turn	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
41:06	269		ZAC	SPEECH	Ja, 26	Learner expressing something	L attention caught by learner expressing something (268)	
	270	38	MELLONY	SPEECH /GESTURE	Cool, so now do you think you could fill in these other ones? ***[pointing to the empty total boxes around the activity grid]*** What do you think this top row will be? We'll just do one. What do you think this top one will be?	M question M gesture		Directing (2a) Promoting joint understanding (2c)
	271		NATE & ZAC	ACTION / GESTURE	***Both boys refer to values written next to symbols and Nate points to each shape on the chart (see*** Figure 31 ***below)***	L action L gesture	L attention caught by m question (270)	
	272		ZAC	SPEECH	8	Learner expressing something in direct response to question (270)		
			NATE & ZAC		***[Nate joins in and they say in unison]*** plus 6			
			ZAC		equals …			
			NATE & ZAC		***[Nate joins in and they say in unison]*** 14 plus another 8			
	273		NATE & ZAC	EXPRESSION	***both giggle***			
	274		ZAC	SPEECH	plus another 8, 14			
	275		NATE	ACTION	***Nate counts on fingers***			
	276		ZAC	SPEECH	22 plus 5 it's 26			
41:36	277	39	MELLONY	SPEECH	22 plus 5?	M question	M attention caught by learner expressing something (272-276)	Prompting (2b)
	278		NATE	SPEECH	26	Learner expressing something in direct response to question (277)		
	279		ZAC	SPEECH	27	Learner expressing something in direct response to question (277)		
	280		MELLONY	SPEECH	22 plus 5?	M question		Prompting (2b)
	281		NATE & ZAC	GAZE	***boys look at each other***	Eye contact L->L		
	282		ZAC	EXPRESSION	***Zac grins at Nate***			

Time	Line Number	Turn	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
	283		ZAC	SPEECH	plus 5?	L question	L attention caught by m question and by L->L eye contact (280 & 283)	
41:44	284		NATE	SPEECH / EXCLAMATION	Aaah	Exclamation	L attention caught by l question (283)	
41:49	285		NATE	SPEECH	27	L statement		
	286		NATE	GESTURE	***Nate makes a hand gesture in confirmation***	L gesture		

Description of what is happening in this event

In line 261, Mellony asks the boys to prove that what they have proposed will work in other places in the puzzle. She specifically directs them to use what they have proposed to work out the totals for another row (line 266). What is interesting is that both boys refer to the values written next to the symbols on their scrap paper, using them as a thinking tool to add up the shapes in the first row (line 271). The '*using symbols*' mediating practice has been used 6 times during this episode and seems to have been taken up by the boys who use it as a tool in the closing stages of the task (line 271). Their workings are shown in Figure 31 below

Figure 31: Nate and Zac's symbolic workings (Episode Two)

In turn 39, the boys make an error in their calculation and Mellony prompts them to think about it by using a prompting question (line 277). Zac realises the mistake but Nate repeats "26" (line 278). Mellony captures his attention by repeating the prompting question and Zac catches Nate's attention by grinning at Nate and asking his own question (line 283). Nate's subsequent utterance is altered by this ("aaah") which is followed 5 seconds later with a revised answer of "27" (lines 284 to 286).

Attention Catching and Mediation

Of note in this event, is that there are two instances where the learners catch each other's attention (lines 268-269 and 283-284). The second instance enables Nate to realise his mistake and revise his answer. Mellony's mediation is mostly focussed on ensuring that the solution can be justified and there is joint understanding between the boys. By focusing on getting the boys to convince her that their numbers work, the process particularly prompts Nate to reflect and revise his answers (lines 278 and 285).

As in episode one, Mellony provides in-the-moment mediation for the learners. She mediates slightly differently for Nate than for Zac, using encouragement as a way of keeping him focussed (critical event 2). She watches quietly when the boys are working together and is guided by what they contribute through expressing themselves and eye contact. Her gestures (of touch and pointing) also act as attention catching mechanisms for Nate and serve as another way to keep him focussed on the task.

Key insights from these three critical events

Watson (2007) suggests that when a learner is supported, through interactions, to take over for himself, the unfamiliar, more complex thinking required to complete a task, he progresses from what is already known to new ideas. Guided by this statement and my own ZPD constructs, I would suggest that a ZPD emerges for both of these boys during this episode.

At the start of the task both boys state they have not seen a puzzle such as this before. With minimal mediation from Mellony at the beginning of the task in terms of explaining the structure of the puzzle and what they need to find out, the boys generally work on their own to solve the puzzle. At strategic points she provides mediation as discussed above such as seeking justification, promoting joint understanding and providing encouragement. The interactions of the boys and the ways that they catch each other's attention as shown in the critical events above ensures that they work collaboratively to eventually solve the puzzle together although this interaction is not evident all the way through the episode. Nate repeatedly looks to Zac to say something, perhaps deferring to him, but in fact it is Nate who makes a breakthrough with finding the value of the triangle (critical event 2). They then work together to find the value of the final shape (club / clover).

It is these interactions that enable ZPDs to emerge for the boys, as they take advantage of the collaborative nature of activity to accomplish what they may not have been able to do on their own (Levykh, 2008 p. 91). Furthermore, both boys progressed through the task from not having seen this type of activity, to solving it (and being able to judge their solution) within the collaborative environment.

In spite of Nate expressing at the beginning that the task would be hard, he found the value of the triangle and proved or justified (occasionally in unison with Zac) when asked to do so. The video (and transcript in Appendix I) also shows that he leans in and out of the desk during the task (in fact during the whole interview) and physical actions and gestures by Mellony engage him more effectively in the task than for Zac. These attention-gaining techniques used by Nate and Mellony have the effect of pulling Nate into his ZPD and keeping him there by focussing and re-focussing him on the task. While I did not assess the extent to which learners would be able to solve similar problems on their own, I suspect that Nate would manage such problems more quickly and easily than Zac.

End of critical events for Episode Two

EPISODE THREE: AKHONA & KUHLE (GIRLS) AT LUHLAZA PRIMARY

The patterns of interaction, attention catching and mediation from the broad analyses of this episode presented in section 6.4 of this chapter lead me to present four critical events from this episode as analytical discussions and were chosen to exemplify the following:

1. No engagement beyond trying to get the correct answer the first time
   Turns 16 to 18 (4 and a half minutes into the task, lines 133 to 151)
2. Offering mediation too soon
   Turns 19 to 23 (3 minutes into the task, line 152 to 191)
3. Responding only to direct questions
   Turns 31 to 32 (approximately 7 minutes into the task, lines 230 to 250)
4. Attention catching and mediation does not work for one of the learners
   Turns 39 to 43 (10 minutes, 33 seconds into the task, lines 287 to 327)

Introduction to the critical events for Episode Three

This episode takes place in the Luhlaza Primary club between Akhona and Kuhle and is facilitated by myself. As in the previous episodes, the girls have completed Tasks 1 and 2 in the interview and have just been introduced to Task 3. Akhona quickly finds the value for the circles (after one minute and 14 seconds). She spends much of the subsequent time working by herself on the second clue (the triangles in the fourth column) and comes up with an answer after six minutes and 15 seconds. She also solves the final clue in approximately 12 minutes.

Note: This interview was interrupted twice when the librarian offered refreshments during the task-based interview and is not relevant to the data analysis. These sections are shown in yellow in the full transcript in Appendix I.

Critical event 1: No engagement beyond trying to get the correct answer the first time

I selected this first event to illustrate how Kuhle does not engage with the puzzle beyond trying to get the correct answer the first time of trying.

After solving the first clue (1 minute and 14 seconds, line 72), the girls are unsure about how to go about solving the next part of the puzzle. From line 73, they make little progress in solving another clue for the next three and a half minutes. In line 99, Kuhle says, “we don’t know these numbers” pointing to the other shapes on the chart. My mediation up to this point has been mostly directing and funnelling as a way of helping the girls find a way forward without actually telling them what to do next. I have just directed them towards the total of 26 at the bottom of the 4th column and prompted the girls to think about if the 2 circles are 5 each, what the triangles might be. The extract below begins at line 133 (4 minutes and 17 seconds into the task).

Time	Line number	Turn	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
04:17	133		KUHLE & AKHONA	GAZE	***Both girls still looking at the chart and what Debbie is indicating***			
	134		AKHONA	GESTURE	***Akhona gestures towards the paper with her pencil and turns the paper towards her***			
	135		KUHLE	EXPRESSION / GESTURE	***Kuhle sighs and points to the 4th column***			
	136		AKHONA	SPEECH	hmm, it’s …	L statement		
	137		AKHONA & KUHLE	GAZE	***girls glance at each other briefly***	Not coded as eye contact as it as brief glance		
04:31	138	*16	KUHLE	GESTURE / GAZE	***Kuhle points to the 26 at the bottom of the 4th column and counts on her fingers, glancing sideways at Debbie as she does***			
	139		AKHONA & KUHLE	POSTURE / ACTION	***Akhona pulls back her sleeves and starts counting on her fingers***	L action		
	140		KUHLE	SPEECH	10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20			
	141			GAZE / ACTION	***Kuhle looks at the ceiling, calculating, then at Debbie***			
04:45	142		KUHLE	SPEECH	13 ***[softly]***	L expressing something		
	143		KUHLE	GAZE / EXPRESSION	***Looking at Debbie, small grin on her face***			
	144		AKHONA	GAZE / ACTION	***Glances at Kuhle briefly, then at Debbie, continues to count on her fingers***	Not coded as eye contact as it as brief glance		
	145	17	DEBBIE	SPEECH	Hmm? Thirteen? Let’s see what Akhona gets ***[talking to Kuhle]***	M statement		Clarifying (2b)
	146		DEBBIE	SPEECH	***[To Kuhle]*** So you are saying that the 2 triangles equal 13?	M question		Clarifying (2b)
	147		DEBBIE	GESTURE	***Debbie points to the two triangles***			

Time	Line number	Turn	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
	148		KUHLE	SPEECH	13	Learner expressing something in direct response to M question (146)	L attention caught by question (146 [41])	
	149		DEBBIE	SPEECH	So here, put 13 for Kuhle. She says "13"	M statement		Directing (2a) Using symbols (3)
	150		DEBBIE	ACTION	***Debbie writes 13 next to the triangle on the key***			
	151	*18	DEBBIE	SPEECH	***[To Akhona]*** You carry on and tell me what you think the 2 triangles are.	M statement		Directing (1)

Description of what is happening in this event

In lines 138 to 141, both girls use their fingers to work out an answer for the triangles in column 4. In line 142 (28 seconds later) Kuhle offers an answer of “13” which I confirm is her proposed answer and record this on scrap paper. I direct Akhona to carry on working out what the two triangles might be.

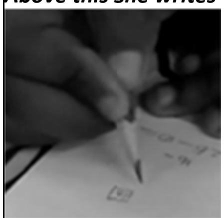
Attention Catching and Mediation

This event shows only one instance where attention is caught (lines 146 to 148). I ask Kuhle a direct question and she responds. I introduce the mediating practice of *using symbols* to keep the girls keep track of their proposed answers. The other mediation is minimal as I watch the girls trying to work out the values for the triangles in the fourth column. Akhona is not distracted by Kuhle’s answer (in lines 142 to 151) and continues to work. Akhona’s focus is a common feature of this episode. She is seldom distracted by Kuhle and stays focussed on the mathematics once she has an idea about how to move forward.

[41] These numbers are a cross reference to the line to which the ACM refers

Critical event 2: Offering mediation too soon

This second critical event is an example of Akhona working on her own to solve the puzzle and illustrates how mediation offered too soon can break the flow[42] of learners' thinking. This next extract follows directly from the previous one and starts at line 152.

Time	Line number	(* indicates start & end of critical	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
	152		AKHONA	GAZE / POSTURE	***Akhona frowns, stares at Debbie, chin in her hand***		L attention caught by statement (151)	
	153		KUHLE	POSTURE / ACTION	***Kuhle sits back and continues to silently count on fingers***	L action		
	154		AKHONA	ACTION	***Akhona also starts to count on her fingers again***	L action		
05:08	155	19*	AKHONA	GESTURE / ACTION	***Akhona picks up her pencil and starts to write on blank paper***			
	156		KUHLE	GAZE	***Kuhle has stopped counting and is looking (indirectly) at Akhona's working, glancing at Debbie and around the room***		Attention NOT caught	
	157		KUHLE	GESTURE	***Kuhle plays with her mouth***			
	158		AKHONA	ACTION	***Akhona continues to work***			
05:22	159		DEBBIE	SPEECH	So what is your answer Akhona?	M question	**** Break in flow**	Asking for verbalisation of thinking (2b)
	160		AKHONA	GAZE / ACTION	***Akhona looks up from her work and then continues to work, talking to herself***	L action		
05:27	161	20	AKHONA	ACTION	***Both girls are silent, Akhona continues to work She has written "26-10=16" at the bottom of her paper Above this she writes "16-"*** 			
05:34	162		AKHONA	ACTION	***Akhona draws a box on her paper and writes "16" in it, all the time whispering to herself***			
05:38	163		AKHONA	ACTION	***Akhona draws two more boxes under the 16, putting the numbers 10 and 6 in each box below the 16*** 			

[42] See ** in the transcript and in the paragraphs below.

Time	Line number	(* indicates start & end of critical	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
05:40	164		KUHLE	POSTURE / EXPRESSION	***Kuhle sits back in her chair, smiling but not doing anything***		Attention NOT caught	
05:43	165		KUHLE	POSTURE / GAZE	***Kuhle puts her chin on the desk and sneaks a look at what Akhona is doing***			
05:44	166		DEBBIE	SPEECH	Okay	M statement		
	167		AKHONA	ACTION	***Akhona continues, uninterrupted***			
	168		MELLONY	SPEECH	***[whispers***] let's let her finish	M statement		
	169		DEBBIE	GESTURE	***Debbie picks up a pencil***	M gesture		
	170		KUHLE	EXPRESSION / POSTURE / GAZE	***Kuhle smiles, sits back in her chair, then grabs a pencil, stands up and looks at Debbie, then around room***			
	171		AKHONA	ACTION	***Akhona continues to work on her paper***	L action		
05:54	172		DEBBIE	SPEECH	Explain what you are doing there, Akhona	M statement	M attention caught by learner action (171) **** Break in flow**	Asking for verbalisation of thinking (2b)
	173		AKHONA	POSTURE / GESTURE	***Akhona sits back and puts down her pencil***	L gesture		
05:55	174	21	AKHONA		***Akhona's workings show her final box is empty*** ***She pauses before answering***			
	175		AKHONA	SPEECH / EXPRESSION	I want a half ***[drawn out]***	L expressing something (in direct response to M statement (172)		
05:58	176		DEBBIE	SPEECH / INTONATION	You want a half? ***[rising intonation]***		M attention caught by learner expressing something (175)	Making talk explicit (2b)
	177		DEBBIE	SPEECH	Okay. So what did you get?	M question		
	178		AKHONA	GAZE / POSTURE	***Akhona looks at her workings and rests chin in her hand***			
	179		DEBBIE	SPEECH	You said 26 minus 10 was 16	M statement		Making actions explicit (2b)
06:10	180		AKHONA	SPEECH	yes	L statement		
	181	22	DEBBIE	SPEECH	and now you are trying to work out what half of this is. Is that what you are trying to do?	M statement M question		Clarifying (2b)
	182		AKHONA	SPEECH	Yes	L statement		
	183		DEBBIE	SPEECH	Okay. So tell me what.. tell me how you've done that then	M statement		Asking for verbalisation of thinking (2b)
06:15	184		AKHONA	SPEECH	***begins to talk but unclear what she says***			
	185		AKHONA	GESTURE / ACTION	***Akhona points to the boxes on her workings and writes "8" in the final one***	L action		
	186	23*	DEBBIE	SPEECH	What do you think half is? You've got your answer!	M statement	M attention caught by action (185)	Prompting (2b) Valuing (1)
	187		AKHONA	GESTURE	***Akhona points to the box at the bottom of her workings which contains an 8***	L gesture		

Time	Line number	(* indicates start & end of critical	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
	188		AKHONA	SPEECH	8	L expressing something (in direct response to M statement (186)		
	189		DEBBIE	SPEECH / INTONATION	Wow, it's 8	M statement	M attention caught by learner expressing something (188)	Encouraging (1)
06:23	190		AKHONA	POSTURE / GAZE / EXPRESSION	***Akhona sits up straight and looks directly at Debbie, smiling***	Eye contact L->M	L attention caught by statement (189)	
	191		KUHLE	EXPRESSION / GAZE	***Kuhle opens her mouth wide and looks at Debbie***			

Description of what is happening in the event

Kuhle gave her proposed answer of "13" for the triangle in the previous excerpt (lines 142 to 148). In this excerpt, Kuhle makes no further progress on the puzzle. She looks around the room (line 156), is silent, plays with her face and mouth (line 157). She glances at Akhona to see what she is doing (line 165) but does not engage with her or what she is doing. She reacts slightly when Akhona gives an answer in line 191.

At the beginning of the excerpt, Akhona starts to work something out on her paper (line 155). After 14 seconds, I ask her to verbalise what she is thinking (line 159) but Akhona is undeterred. I try again 22 seconds later (at line 166) to gain access to her thinking but Mellony (who is recording the video) says "let's let her finish". My attention is caught by what Akhona is doing on her paper (lines 171 and 172). This time, Akhona responds directly to my statement even though she hasn't finished her process as the final box of her working is empty (line 174). She explains that she wants "a half". I ask her what she got (line 177), but because she hasn't finished she doesn't have an immediate answer.

In line 185, Akhona finishes her workings and writes, "8" in the final box on her paper and verbalises "8" (line 188). When I encourage her, she sits up straight, smiles and looks directly at me. At this point, Kuhle looks at me but doesn't say anything. Akhona's final workings for finding half of 16 are shown in Figure 32 below.

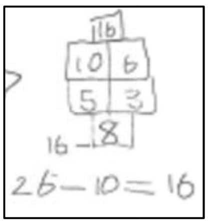


Figure 32: Akhona's final workings for finding half of 16 (Episode Three)

Attention Catching and Mediation

This event is characterised by my attention being caught when Akhona expresses herself (for example lines 175 and 188) or by her workings on paper (mathematical actions in lines 171 and 185). These instances lead to subsequent mediation, which is focussed on getting Akhona to verbalise her thinking (making her talk explicit). I also use level 1 mediational practices to value and encourage Akhona (lines 186 and 189). My final statement “Wow, it’s 8” catches Akhona’s attention which is evidenced by her sitting up straight, smiling and making eye contact with me. This does not seem to have any effect on Kuhle as she does not alter her posture or say anything further.

Akhona directly contributes to the interactions in many ways: by mathematical action (her workings on paper), by expressing herself and by making statements and gestures. However her primary contributions are her mathematical workings (actions). I note that she only contributes when she is ready (lines 172 onwards). For example, in line 159, I ask her what her answer is but she doesn’t respond, she continues working. This shows that she is focussed on the mathematics. Once she responds, her attention is caught by my mediation using questions and statements and she tries to verbalise what she is doing. This mediation leads to her realisation (line 190) that she has actually worked out the value for the club.

Small notes in lines 159 and 172 of the transcript indicate “** Break in flow”. For me this analysis shows how the flow of a learner’s concentration can be interrupted by asking questions too soon. In this event, Akhona is focussed enough to ignore me (line 159) and continue working on her solution. However lines 172 to 174 reveal that my question interrupted Akhona as she had not yet arrived at a solution. Her answer (line 175) additionally reveals that she still is not sure what her answer will be. This type of break in flow can unsettle a learner’s thinking and cause a fragile ZPD to be disrupted. I will return to this idea in the discussion at the end of this section and this chapter.

Kuhle on the other hand does not seem to be engaged. She does not contribute verbally in this excerpt. However, her *gaze-based* interactions are worth noting. In the entire episode her gaze-based interactions make up 31% of her total interactions. This transcript extract shows the use of the word ‘*glance*’. Kuhle glances at me, at Akhona’s workings, around the room (lines 156, 165, 170, 191 for example) but I argue that this is not focussed looking, (i.e. it is not looking with a purpose, with awareness or engagement). As a result, I have made the distinction in this episode between *eye contact* (which can be considered an ACM) and *glancing*. Eye contact is held, is done with awareness and indicates engagement.

Kuhle is not mathematically active (see for example lines 157 and 157) in this excerpt: she sits back in her chair (lines 153, 164, 170), puts her chin on the desk and so on. My valuing of Akhona’s contributions (lines 186 and 189) does not seem catch Kuhle’s attention in a significant way.

Critical event 3: Responding only to direct questions

I chose this event to exemplify how Kuhle responds to direct questions but is not self-directed as in the case of Akhona.

What has happened since the last event

Prior to this excerpt (see Appendix I), I ask Akhona to verbalise her thinking and try to draw Kuhle into the activity (line 198) by asking, "do you see what she is doing?" Kuhle answers "yes" but does not engage further. I continue to make Akhona's actions explicit and clarify her contribution (lines 203 to 216). I ask Kuhle if she agrees. Again, Kuhle answers "yes" but does not engage further.

In lines 221 to 223, Kuhle records Akhona's answer by writing 8 for the triangle next to the key on the activity sheet. In line 224, I say, "now see if you can work out the last one. What is the club going to be?" In line 230, Mellony whispers to me "does she change it?" (asking, does Kuhle change her answer of "13" given in line 148). We pick up the transcript at line 235.

Time	Line number	Turn	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
	235		DEBBIE	SPEECH	***[To Kuhle]*** Come here. You put 13	M statement		
	236		DEBBIE	GESTURE	***Debbie indicates Kuhle's earlier answer on the corner of the activity sheet***			
	237		DEBBIE	SPEECH	***[To Akhona]*** You carry on. You just think about it			Directing (2a)
	238		DEBBIE	SPEECH	How did you get 13?	M question		Excavating (2b)
	239		KUHLE	SPEECH	I halved 26	L statement		
	240		KUHLE	GAZE	***Kuhle looks at Debbie***			
	241		DEBBIE	SPEECH	You halved 26.	M statement		Clarifying (2b)
	242		DEBBIE	SPEECH	Okay. Halved 26... Um, so would you change this now that you saw the way Akhona did it? Would that still be your answer?	M question		Excavating (2b)
	243	32*	KUHLE	EXPRESSION	***Kuhle shakes head very slowly***			
	244		KUHLE	SPEECH / INTONATION	No ***[very softly]***	L statement		
	245		AKHONA	EXPRESSION / POSTURE	***Sighs loudly and sits back in her chair***			
07:59	246		DEBBIE	SPEECH	So you would change it? Can you see what she did, because with your way um, didn't take those	M question M statement		Asking for reflection on what is seen (2b)
	247		DEBBIE	GESTURE	***Debbie indicates the circles in the 4th column***			
	248		DEBBIE	SPEECH	you didn't think about what that was did you? You took the whole thing, is that what I understand what you did?	M statement		Making actions explicit (2b)
	249		KUHLE	SPEECH / INTONATION	Yes ***[very softly]***	L statement		
08:09	250		DEBBIE	SPEECH	Okay, alright. Carry on then.	M statement		Directing (2a)

Description of what is happening in the event

I turn my attention to Kuhle and I direct Akhona to continue thinking about the last value (line 237). I ask Kuhle about her original thinking using excavating and clarifying (lines 238, 241 and 242). In line 242, I ask Kuhle if that (13) would still be her answer based on what Akhona proposed. Kuhle softly answers “no” but does not elaborate. I ask her if she can see what Akhona did, seeking for her to reflect on what she has seen (line 246). I attempt to put Kuhle’s actions into words by saying “you didn’t think about what that was did you? You took the whole thing, is that what I understand what you did?” Kuhle again answers very softly “Yes” (line 249).

In line 245, Akhona sighs loudly and sits back in her chair.

Attention Catching and Mediation

Prompted by Mellony’s suggestion, in this event I am focussed on getting Kuhle to reflect on Akhona’s answer for the triangle and to see if she will change her original answer of “13”. I use excavating, clarifying and reflection mediational practices. Kuhle responds directly to my questions in brief statements (for example “I halved 26”) and gives one-word answers (line 244 and 249). The transcript does not indicate any interactions apart from *speech* and *intonation*, suggesting that Kuhle’s attention seems aimed at simply and briefly (and softly) answering the questions; perhaps giving me the answers she thinks I want, rather than focusing on the mathematical activity itself.

Critical event 4: Attention catching and mediation does not work for one of the learners

In this final critical event for these girls, I illustrate that attention catching and the style of mediation I offer only works for Akhona. She works on her own, finding the value for the clubs without input from Kuhle.

What has happened since the last event

Within the next two and a half minutes, I attempt to pull Kuhle back into the activity as Akhona is intently working on finding the value for the clubs (lines 275, 280, 285, 286). In line 272 I say: “Kuhle, have you got an idea? Or were you just going with what Akhona thinks?” Kuhle answers “yes” and plays with her pencil. In line 276 I suggest, “maybe you could think of a different way?” Kuhle responds by grabbing a piece of paper (line 279) and starting to write something. She continues to glance at Akhona, make faces (line 283) and occasionally looks at the activity (line 282). This critical event joins the transcript at 10 minutes and 33 seconds into the activity (line 287) where Akhona is trying to find the value for the clubs.

Time	Line number	Turn	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
10:33	287		AKHONA	GESTURE / GAZE / ACTION	***Points to top row of chart, looks at it intently, writes a number next to the club (could be a 6)***	L action		
	288	39	KUHLE	POSTURE / EXPRESSION	***Leans back, coughs, leans in***			
	289		AKHONA	ACTION / GAZE	***Begins to count on her fingers, looking at Debbie***	L action Eye contact L->M		
10:41	290		KUHLE	ACTION	***Counts on her fingers***	L action		
10:43	291		DEBBIE	SPEECH	Okay, if you think it's that	M statement	M attention caught by action (287 & 289)	Directing (2a)
	292		DEBBIE	GESTURE	***Points to the number next to the club that Akhona wrote next to***			
	293		DEBBIE	SPEECH	Just test it with other places	M statement		
	294		DEBBIE	GESTURE	***Points to other clubs on the chart***			
	295		AKHONA	GAZE	***Looks at Debbie***	Eye contact L->M		
	296		DEBBIE	SPEECH	to see if it works	M statement		
	297		DEBBIE	SPEECH	So you said it might be 6			
	298		AKHONA	GAZE / EXPRESSION	***Continues to look at Debbie, grinning slightly***	Eye contact L->M		
	299	40	DEBBIE	SPEECH	So now try it in other places	M statement		
	300		DEBBIE	GESTURE	***Indicates the chart generally***			
	301		AKHONA	GAZE	***Looks at the chart***			
10:55	302		DEBBIE	SPEECH	Add them up and see if it is six Because that's how you test your idea	M statement		Directing (2a) Modelling (2b)
	303		AKHONA	GESTURE / POSTURE	***Points to 2nd row and leans into the chart***		L attention caught by statements (299 & 302)	
	304		KUHLE	GAZE / EXPRESSION	***Keeps glancing at chart, sticks out her tongue, but doesn't write anything further on her paper***		Attention NOT caught	
11:05	305		AKHONA	ACTION	***Writes numbers next to the shapes on the chart, talking to herself as she does so***	L action	L attention caught by statements (299 & 302)	
	306		AKHONA	GAZE / ACTION	***When she gets to the triangle at the end of the 2nd row, she references her workings, writes 8***			
	307	41	KUHLE	GAZE	***Continues to be silent but glances at the chart briefly***			
	308		AKHONA	POSTURE / ACTION	***Sits back, counts on her fingers***			
	309		AKHONA	SPEECH	8	Learner expressing something		
11:20	310		KUHLE	EXPRESSION / GAZE	***Has her thumb in her open mouth, looks at Debbie***			
11:26	311		AKHONA	EXPRESSION / GAZE	***Has an intake of breath, grins, looks at Kuhle***	Eye contact L->L		
	312	42	KUHLE	GAZE	***Looks at Akhona***	Eye contact L->L		
	313		AKHONA	GESTURE / EXPRESSION	***Gives a thumbs up and smiles broadly***	L gesture L expression		
	314		AKHONA	ACTION	***Continues to count on fingers***	L action		

Time	Line number	Turn	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
11:33	315		KUHLE	GESTURE	***Plays with her fingers***		Attention NOT caught	
11:39	316		AKHONA	ACTION / POSTURE / GAZE	***Writes a total for row 1, sits back and looks at Debbie***	L action Eye contact L->M		
	317		DEBBIE	SPEECH	Does this one add up to 25?	M question	M attention caught by sequence (311-316)	Prompting (2b)
	318		DEBBIE	GESTURE	***Points to row 2***			
	319	43*	AKHONA	SPEECH	Yes	L statement	L attention caught by question (317)	
	320		AKHONA	GAZE	***Maintaining eye contact with Debbie***	Eye contact L->L		
	321		DEBBIE	SPEECH	Does it? Let's just do it.		M attention caught by statement and by eye contact (319-320)	Prompting (2b) Directing (2a)
	322		DEBBIE	GESTURE	***Grabs a pencil***			
	323		DEBBIE	SPEECH	6 and 6 is..?	M question		Prompting (2b)
	324		DEBBIE	GESTURE	***Points to 2 clubs***			
	325	44	KUHLE	SPEECH	12	L expressing something in direct response to m question	L attention caught by question (323)	
	326		AKHONA	SPEECH	12			
	327		AKHONA	GAZE	***looks up at Debbie***	Eye contact L->M		

Description of what is happening in the event?

Akhona catches my attention by writing a number next to a club on the activity paper (line 287), which could be a 6. I follow up by indicating that she should test the idea of the club being a 6 in other rows or columns (lines 291 to 302). Eye contact is made between Akhona and myself (lines 295, 298).

Kuhle is not engaged (lines 304 and 310) until Akhona looks at her (line 311). Kuhle then looks at Akhona, who smiles and puts her thumb against her chest[43] (line 313). She writes a total for row one (line 316) then makes eye contact with me (line 316). This sequence of learner-to-learner eye contact and Akhona's actions catch my attention. I ask Akhona if row two adds up to 25 (line 317). Akhona answers "yes", all the while looking at me. I prompt her to check it, and grabbing a pencil myself go on to check it with her. Kuhle joins in (line 325) in direct response to my question in line 323.

[43] This is a gesture used in the clubs to indicate that the learner has answer they wish to share.

Attention Catching and Mediation

In this event both learner and mentor attention is caught. When my attention is caught this leads to subsequent mediation. Of note is that this mediation only catches the attention of Akhona. For example, when I mediate in line 291, only Akhona actively responds with eye contact, actions and by expressing herself (lines 298 to 316). Akhona tries to catch Kuhle's attention by making eye contact with her (line 311) but this does not seem to engage Kuhle. In the subsequent lines Akhona continues to actively engage but when I ask a direct mathematical question ("6 + 6 is?") that requires a simple calculation, a direct answer, and does not require reference to the puzzle, Kuhle's attention is caught and she (and Akhona) respond with an answer (line 325).

The mediation in this event is a mixture of *funnelling* (level 2a) and *reviewing* (level 2b) practices with a focus on getting the girls to ensure that numbers add up correctly. With these practices, the mediation is hence more traditional or more transmissive in nature and perhaps does not move learning forward for either of the girls. Kuhle's response to my question does not lead to any progress in solving the problem at hand. Kuhle seems to respond to direct mediation such as when she is asked a direct question (for example line 325) or asked to do something specifically. She does not seem to respond to a more flexible or open approach. For Kuhle participation seems to be about getting the answers right, not about clarifying her own understanding or sustained effort in trying to solve a problem. In these events, we see little effort on her part to engage with the mathematics of the activity. Once she has contributed an answer, she sits back and looks around. We see too that she keeps glancing at me, perhaps wanting me to intervene or make some kind of judgement about a contribution. When I do not do this, she lapses back into silence or inactivity and her participation is characterised by these silences and periods of non-contribution.

Key insights from these four critical events

Simone and Virgona suggest that

> *students who are most dependent on teacher support might be expected to be working at the margin of their ZPD, requiring the teacher to model, prompt, demonstrate, or coach, in order to come to new understandings and insights (2003, unpaged).*

This could be the case for Kuhle in this episode. She responds well to prompting and directing but is dependent on me to move her forward so perhaps she is operating at the margin of her ZPD. Greeno (1994) talks of *attunements* which describe regular patterns of participation. These attunements are shaped by past patterns of participation. Kuhle's regular patterns of participation in these video episodes and from observation in the club sessions suggest that she prefers to work according to the mathematical rules she has been taught and knows, to get the answer right the first time. Often she 'reads' me to determine if she has achieved this as evidenced by her glancing continually at me in the video.

Akhona on the other hand seems to be focussed on (or attuned to) the mathematics and when I catch her attention, the mediation seems to work for her. She contributes directly and is able to reflect on what she has done and does try to verbalise her thinking. I suggest that her direct contributions and sustained interest in solving the task means that a ZPD emerges for her in this episode. When I try to mediate in lines 159 and 172 of critical event two, this interrupts Akhona's thought processes. I stated above that this type of break in flow could disrupt a fragile ZPD. However, based on the fact that Akhona went on to solve the puzzle, I would argue that her intense focus created a robust ZPD for her, one which was not disrupted by my interruptions or by the broader interruptions in the episode.

This brings section two to a close, having presented critical events from each of the three episodes. I have discussed whether ZPDs have emerged or not for each learner and have described the key mediation that comes to light. In the section below, I now discuss all the data presented in this chapter to address research question two.

End of critical events for Episode Three

6.6 DISCUSSION

In this closing discussion for the chapter I draw on the narratives of the selected episodes critical events (section 6.5) and the broader quantitative data presented in section 6.4. I focus on key findings from both sets of data under four headings: 1) ‘tuning in’, 2) attention catching and mediation, 3) sustainment of ZPDs and 4) the relationship between the ZPD and consolidation of existing and new learning.

1. Tuning in

Roth and Radford (2010) talked about a “willingness to tune ourselves to others, to commit to a common cause, and to engage in a manner that is other-oriented” (p. 305). They talk of participants who keep adjusting towards the other through words and “bodily actions and reactions, such as grasping, touching and pointing” (p. 305). Some researchers (Jaworski & Potari, 2009; Lerman, 1996; Mercer, 2007; Steffe & Thompson, 2000; Wells, 2002) would perhaps call this “intersubjectivity” which can be described as finding common ground on which to build a shared understanding.

However, intersubjectivity did not resonate with my video analysis. Instead I noted more of Roth and Radford’s notion of a willingness to tune ourselves to others in the video episodes. Thus, drawing on the work of Roth and Radford (2010) and others mentioned above I have chosen the metaphorical phrase of ‘*tuning in’* to describe what I saw through my analysis. *Tuning in* could be seen as periods of interaction where two or more participants continually adjust to each other in order to communicate mathematically. For example in Episode One, Anathi and Thembela listen to each other, which keeps them interested and motivated to complete the task. With Nate and Zac in Episode Two, we see examples of this tuning in when Mellony notices that perhaps Nate is dis-engaging (or tuning out) and uses attention-gaining techniques (such as touch) and encouraging mediation to pull him back into the activity and to re-focus him.

Tuning out could be seen when a participant is not willing and simply does not make the effort to adjust and engage with the other participants in a mathematical way. We see examples of this tuning out with Kuhle in Episode Three. I attempt to draw her into the activity by asking questions about how she arrived at an answer. However, Kuhle responds in a restricted manner and does not seem to be willing to fully engage with the mathematics of the activity but complies in responding when asked a direct question.

Tuning in resonates with the notion of catching attention in that it reflects periods of sustained mathematical conversation either between the learner and mentor or between the learners themselves and uncovers instances where they communicate their ideas and / or reasoning to each other (Lerman, 2001). Additionally, the notion of tuning in can be a key factor in the relationship between new learning and consolidation of existing learning. I discuss these connections below.

2. Attention catching and mediation

Meira and Lerman (2009) linked the emergence of a ZPD as dependent on participants catching each other's attention. Attention catching mechanisms give clues about the nature of communication between participants in a learning activity and allow us as researchers to make sense of this communication. This led me to ask: in what ways do the participants catch each other's attention and subsequently communicate mathematical reasoning and ideas to each other during the task-based interviews?

In section 6.4 I discussed that overall mediation practices across the episodes were generally centred on clarifying the learners' own understanding of the mathematics they encountered in this task. I also noted that Mellony and myself primarily used questions and statements to catch learner attention and learners primarily expressed themselves to gain our attention and the attention of other learners in the interview. Of particular note is that the task itself was sufficiently captivating to act as an initial ACM for the learners in both Elmtree Prep episodes.

However the quantification of mediation practices illuminated only one part of the story. For me the deeper question was how the mentors took advantage of the moments when attention was caught and how they followed up with mediation. Vygotsky sought to understand why a learner was able to do more in collaboration than independently and he therefore sought to understand the meaning of the assistance offered (Chaiklin, 2003). In this regard I specifically asked three questions:

1. How do the learners respond to the mediation offered?
2. How do the mentors take action to help the learners construct, deepen, solidify and consolidate their learning?
3. How does the mediation enable or constrain the emergence of ZPDs in learners?

How do the learners respond to the mediation offered?

The learners showed varying degrees of response to the mediation ranging from meaningful and noteworthy responses to insignificant responses. For example, Anathi and Nate responded in a mathematically meaningful manner to the mediation offered during their interviews. Anathi responded to requests to verbalise her thinking and managed to do this. Nate, who frequently altered his posture to show that he was disconnecting from the activity, was pulled back in and encouraged to continue by attention catching mechanisms (such as touch and gestures) and mediation (encouragement).

Zac and Thembela had some moments when they responded to the mediation and in general I would argue that they were both engaged although not always actively. They were aware of what the other learner and mentor were doing and seemed to be keeping track of what was going on. Akhona was focussed on her own way of solving the problem but when she decided to take advantage of the mediation at particular places in the interview, she benefited from it.

Of the six learners, Kuhle had the least meaningful response to the mediation offered in the task-based interviews and this suggests that the mediation offered in the task-based interview was largely ineffective for her and I got the sense that she would prefer it to have been different. Below I present a vignette of Kuhle to exemplify the different preferences for forms of mediation that learners may have.

Kuhle's vignette

Kuhle's attention was not initially caught by Task 3, nor was it caught for any prolonged period at any later point. I argue that the mediation I offered was inappropriate for her and as such constrained the emergence of a ZPD. Perhaps Kuhle could be described as "compliant" which Graven (2013) defines as equating "mathematical success with teacher dependence, compliance and careful listening rather than relating it to independent thinking, problem solving or making sense of mathematics" (p. 6). It is likely that Kuhle feels comfortable in her knowledge of giving the teacher (or adult in charge) what she thinks they want in the form of answers to straight-forward calculations but is not so comfortable with steering away from this to more open ended and unfamiliar problem solving. Barnes (2010) describes these types of learner responses as "right answerisms" (p. 7) where the learner essentially gives back to the teacher what has already been said or what the learner thinks the teacher wants to hear.

Additionally, Graven (2013) argues that "passive compliant learning dispositions" (p. 6) and compliance can come at the expense of agency. This resonated with my articulated notion of the ZPD where I highlighted learner agency in terms of benefitting and taking advantage of assistance from others. I propose that Kuhle's compliance with more traditional mathematical practices (at which she is successful), comes at the expense of her agency and she is does not take advantage of the type of mediation offered in these interviews and in the club sessions to further or deepen her understanding or to promote new learning. This type of mediation assumes some agency to contribute ideas on to how to solve a problem. Perhaps what was needed with Kuhle was individualised one-to-one mediation focused on the development of her own agency.

Previously I spoke about mathematical forms of participation. Learning in a participation-based environment such as these after school maths clubs is very different to that of a traditional classroom and learners are required to contribute different aspects of themselves as well as contributing more of themselves (Boaler, 2002). I argue that Kuhle struggled with this changed form of participation both in the task-based interviews and in the club sessions themselves. An example will help to illustrate. From the very first club session, I encouraged the learners to call me by my first name. Most of them enjoyed this idea and did so for the whole year. Kuhle on the other hand continued to call me "teacher" until the end of the year and continued to do so in the second year of the club in 2013. Entries in my research journal also reveal that she resisted pairings in sessions with learners she considered to be slower than her and she often scoffed at incorrect answers given by other clubs learners.

How do the mentors take action to help the learners construct, extend, deepen, solidify and consolidate their learning?

Looking across the qualitative analysis of the critical events the mediation seemed to arise from "in-the-moment micro-decisions" (Watson, 2007, p. 118) made by Mellony and myself based on how our attention was caught by the learners rather than being purposefully planned. Askew (2012) suggested that teachers are "frequently presented with 'offerings' to which they have to respond" (p. 37) and pointed out that if the teacher can let go of the need to be in control then something "richer and more interesting" (p. 37) can emerge from a mathematical interaction. This seems to support what was happening in these episodes. The mentors were presented with many 'offerings' (mostly when learners expressed themselves), which captured their attention. They responded with mediational practices. Neither Mellony nor myself seemed to have a pre-planned idea of where the mathematical conversation was going; rather we were guided by what the learners contributed or offered. This can be a problem for learners like Kuhle whose lack of agency means they make few contributions apart from calculating numeric answers and offer little in the way of proposing mathematical ways of working.

I would argue further that the mediation evident in the selected episodes was never unintentional; rather it provided an extended range of interactions to the learners and was focused on providing challenges for the learners. Goos (2004) echoed what is illustrated here, saying that in situations like this, sequencing in a learning activity becomes a "reorganisation of social interactions" (p. 263) rather than a series of pre-planned teaching sequences. The flexibility in providing mediation seems to cohere with what researchers such as Anghileri (2006) and Verenikina (2008) called for with regard to scaffolding practices being more creative, flexible and dynamic so that mediation (scaffolding) can be "responsive to the emerging learner within the social group" (Anghileri, 2006, p. 51).

What is the nature of the mediation?

In order to address the first part of research question two, I return to the notion of *tuning in*. If tuning in is seen as periods of interaction where two participants continually adjust to each other in order to communicate mathematically, then it follows that where this occurs participants are engaged. Conversely, disengagement connects to *tuning out*. I argue from the data presented, that there are two types of engagement when participants are tuned in: direct and indirect engagement.

Direct engagement is more active and takes place when participants are communicating mathematically either verbally or by doing something mathematical. This type of engagement connects with the coded ACMs of learners expressing themselves and mathematical action (writing, working out on paper, counting on fingers etc.). *Indirect engagement* is more passive and takes place when participants are not necessarily contributing directly to the mathematics but they are still engaged in the task. This can be seen through making eye contact with fellow participants, listening to each other and making the occasional relevant contribution to the mathematical conversation. Table 33 summarises these three types of engagement as seen by my video analysis.

Table 33: Connecting 'tuning in', attention catching and mediation

Tuning in ➔ Engagement		**Tuning out ➔Disengagement**
DIRECT *Communicating mathematically* Learners expressing themselves Mathematical action	*INDIRECT* *Marginal mathematical communication* Eye contact Listening Occasional contributions	No effort to adjust or engage with the other participants or with the mathematical activity promoted / presented
More active and engaged in the mathematics which	**More passive, observing or sitting on the side-lines which**	
ENABLES MEDIATION THAT: Clarifies and deepens learners existing understandings Restructures and extends existing understandings Develops new conceptual understandings	**ENABLES MEDIATION THAT:** Clarifies and deepens learners existing understandings Assists learners to build their confidence and practice / use existing knowledge and skills	**CAN LEAD TO MEDIATION THAT:** Encourages *Funnelling* type practices such as explaining, telling, showing, directing etc.

The analysis presented in this chapter gives examples of many different kinds of mediation practices ranging from encouragement through to development of conceptual discourse. I argue that different types of mediational practices suit different stages of tuning in and out as illustrated in the table above. For example, when learners are *directly tuned in* to the activity and to each other, opportunities exist to mediate in many different ways: to clarify and deepen existing understandings, to restructure and extend existing understandings or to develop new conceptual understandings. When learners are *indirectly* tuned in, mediation is enabled that looks at how to support learners to build their confidence and practice using existing skills and knowledge. When learners are disengaged, mediation takes on the form of encouragement to encourage the learner to re-focus on the task or reverts to the more 'traditional' practices of telling and explaining.

Furthermore, in light of this notion of tuning in, what seems to be equally important to the specificity of the mediation practices used is the *manner* in which mediation is offered. Thus I argue (using some examples from the selected episodes) that mediation centrally involves:

1. Selection of task / activity
2. Awareness of learner tuning in or out (engagement or lack of engagement) in the activity and the type of mediation that this engagement enables

These two aspects were not evident in the DEST practices (Victoria Department of Education and Early Childhood Development, 2004) discussed earlier, although Anghileri (2006) does mention in her literature review that "careful selection of the task at just the right level of difficulty with the right balance of general ease but some challenge" (p. 36) is important. Additionally she talks of different types of tasks that teachers can use to structure indirect mediation in her section on level 1 scaffolding practices.

Based on this analysis, I take her suggestions further and argue that mediation itself thus *begins in the selection of the task* that forms the basis of the activity, with the purpose of catching learners' attention. The task discussed in the episodes above initially captured five of the six learners attention. If, as I have proposed that all development of the individual comes about through sign mediation in activity (following Vygotsky, 1978) and that the ZPD emerges (or not) in the activity (following Meira and Lerman 2009), the task or activity itself provides the context in which this can happen and for analysing how the participants interact and communicate. As Lerman (2014) puts it "the teacher needs to hypothesize the student's knowing in order to devise an activity so that a ZPD might emerge" (p. 22).

The analysis presented in this chapter reveals that mediation involves *awareness* of the direct contributions that the learners make to the learning activity. Mediation is subsequently about offering flexible, timely responses to those contributions. We saw this for example, with Anathi's initial interest in the activity. Her continued success in solving various clues in the activity (enabled by my mediation and key catching attention instances) meant that a ZPD emerged for her and was sustained throughout the episode. I did not create the ZPD for her; rather we co-constructed it as a result of her own direct contributions. Further her ZPD was sustained by the way in which I responded to those contributions at that moment, in a continual tuning in cycle. On the other hand, the absence of Kuhle's active contributions and thus her lack of agency meant that no ZPD emerged for her as she was neither directly engaged nor tuned in to Akhona or myself.

Mediation is therefore about being mindful of when learners are engaged and disengaged from the activity. Mentors hence can use a combination of mediational practices (such as encouragement) and attention catching mechanisms (such as touch) to draw the learner back into the activity and encourage engagement. For example the video showed Nate leaning in and out of the desk during the task and Mellony's physical actions and gestures urged him to stay focused in on the task.

With regard to engagement, effective mediation requires being able to identify when learners are deeply engaged in the activity and should be left to work on their own and when to intervene. For example Zac quickly found the value for the circle and this success in solving a clue, uninterrupted flow and the attention catching between the boys enabled a ZPD to emerge for Zac. Another example is of Akhona. Her attention was immediately caught by the activity and by my initial mediation and she found the value of the circle quickly. Even when I interrupted her thoughts, she was engaged enough in the task to stay focused and was not side-tracked by the interruption. Again this success in solving a problem (or in this case a series of clues), having an idea for how to move forward with solving the problem, her sustained engagement throughout the task and key attention catching instances allowed a ZPD to emerge and to be sustained for her. This activity was a challenge for Akhona but as the transcript shows, one that she could accomplish with assistance. Although she worked mostly on her own, she took advantage of the mediation offered at certain key points.

3. How are ZPDs sustained?

Meira and Lerman (2009) pointed out that the ZPD is "often fragile and where it is sustained, a process of sign mediation and interaction emerges" (p. 217). Here I include some insights from this analysis that suggest how ZPDs might be sustained that echo this statement. From this discussion of the various ZPDs that emerged for the six learners, I have noted and thus argue, that once attention is caught and a ZPD emerges, it can be *actively* sustained in a number of different ways:

1. by flexible and responsive mediation
2. by further attention catching instances
3. by continued engagement and focus on the mathematical task
4. by the experience of success in solving a problem
5. by continual tuning in

Each of these has been exemplified through this analysis and in the preceding discussion.

4. The relationship between ZPD, mediation and 'flow'

From this analysis and from my experience of working with the learners in the clubs, I came to realise that, in a learning process there cannot constantly be challenge and new learning. Sometimes learners need consolidation, opportunities to practice what they know and strengthen their fluency. Learners sometimes require the opportunity and space to build their confidence in being able to use, apply and communicate what they already know. Following my analysis of these episodes, I call this metaphorical space *'flow'*. I propose that when a ZPD emerges, this could be represented by a vertical axis, symbolising a learner being pulled into new learning and potential development. If a ZPD does not emerge, we could talk about 'flow', which occurs on a horizontal plane and represents strengthening of foundations: consolidation, sense making, practice and application.

This notion of flow first appeared in a reflective discussion between Mellony and myself after the first task-based interview at Luhlaza Primary in 2012. We were specifically reflecting on how the mediation had interrupted Akhona's flow of thoughts. A tension for myself as the mentor was how to recognise when this flow was taking place and not jumping in too soon with mediation. As noted, jumping in too soon can cause a disruption to the flow by pulling a learner away from their own thoughts, preventing them from using their own methods and thereby losing opportunities for consolidating and building their confidence to solve a problem their own way.

Mellony and I subsequently spoke about this notion and in the analysis I have found it valuable for explaining what could happen if a ZPD does not emerge for a learner and yet the learner is not tuned out or disengaged. In such instances I noted that the learning activity was not a waste of time. Thembela provides examples from the video. She did not contribute new ideas during this episode but she seemed comfortable using, applying and communicating what she already knew. I got a sense that she allowed Anathi to be the active participant and to take over solving the majority of the puzzle. Figure 33 illustrates this relationship between the ZPD and flow.

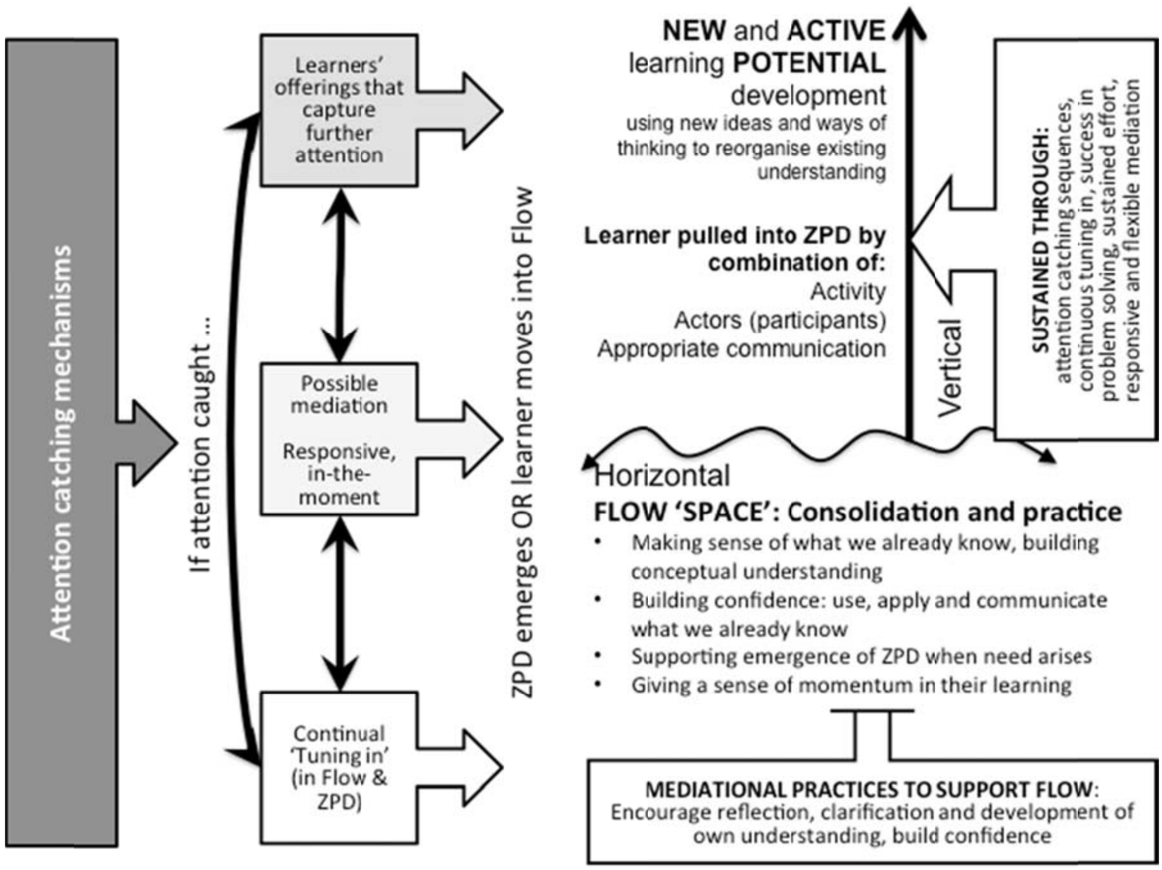


Figure 33: The relationship between ZPD, mediation and flow

If mentors are aware of learners being in 'flow', their selection of mediational practices to support the learner to build confidence and understanding becomes important as Anghileri asserts:

> *enabling students to develop their own meanings in these ways can have long-term benefits in enhancing their confidence and independence in learning (2006, p. 42)*

Reviewing practices (Anghileri, 2006) would be suited to supporting learners in 'flow'. Anghileri describes these as those that are "more responsive to the learner" (p. 41) and give learners the opportunity to develop their own understanding rather than relying on someone else to do so. These reviewing practices are additionally intended to encourage learner reflection and clarification but do not alter existing understanding. Examples of these practices are prompting, probing, seeking explanation and reflecting on mathematical actions and talk. Many of these were evident in the analysed episodes and were shown as the principal practices used by both Mellony and myself across all three episodes.

In the club programme design discussed in Chapter Three, the Zone of Promoted Action (ZPA) described the activities that were promoted in the clubs. In the task-based interviews, the learners were offered learning activities that were challenging and were at the edge of their development. Looking at the full video data for all tasks from the task-based interviews, I saw that the promoted activities worked in different ways for different learners at different times during the interview. Sometimes the activity built learner confidence in being able to demonstrate what they already knew; sometimes the activity served a consolidating function for the learner in terms of strengthening their learning, and sometimes the activity was challenging enough for a ZPD to emerge and for potential new learning (and possibly development) to take place.

In the data presented from the episodes above, all six learners noted that they had not worked with a puzzle such as this before. For four of the learners in these task-based interviews (Anathi, Zac, Nate and Akhona) I suggest that the activity assisted in pulling them into a ZPD and that possibly new learning took place for them. For Thembela, this activity perhaps allowed her to consolidate and practice related calculations and to be in the flow. For Kuhle, I suggest she was neither in a ZPD nor in the flow.

In earlier discussions of zone theory and following the findings of the pilot club, I presented the ZPA, ZFM and ZPD as shown in Figure 34 below with the ZPD foregrounded as the focus of my study. I suggested that the ZPA and ZFM zones were not equal to the ZPD but played a supporting role in its emergence.

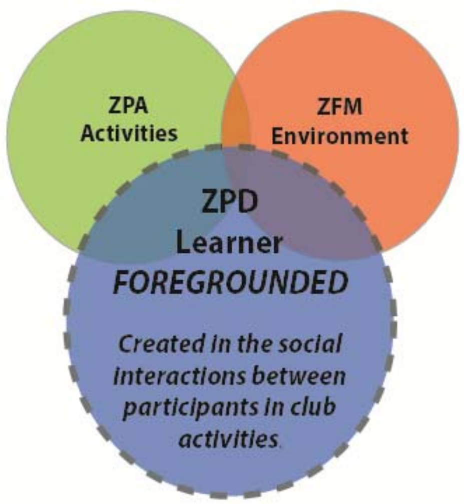


Figure 34: ZPD zone foregrounded

However, perhaps for learners such as Thembela, in those instances when a ZPD does not emerge for a learner, the ZPD zone may be replaced by a zone called *FLOW,* which is also supported by the ZPA and ZFM as shown in Figure 35 below.

Figure 35: FLOW zone foregrounded

6.7 CHAPTER SIX: CLOSING REMARKS

In this chapter I presented and analysed data for research question two. Data was presented from a broad perspective in section 6.4 and then using in-depth transcripts of selected video episodes in section 6.5. In doing so, I looked at the significance of tuning in, attention catching mechanisms and mediation as a way of enabling the emergence of a ZPD and as a way of sustaining a ZPD. I spoke too about the role of flow, which was a possible mechanism for explaining what happens when, in some cases a ZPD was not created but learners remained engaged in the activity.

There are two further avenues emerging from the data presented in this chapter that I wish to explore before I conclude this chapter: these are the relationship between learning and multimodality and speaking back to the theoretical concepts of the ZPD presented in Chapter Two.

Learning and multimodality

Roth (2001) highlighted a trend in communication research, which includes multimodal approaches. These approaches aim to understand the “complex interactions that characterise human communication” (p. 368) and are becoming increasingly prominent in mathematics education research. In these episodes I argued that mediation took place primarily using *verbal* modes of interaction as the tables in the earlier sections of this chapter reveal. Both Mellony and I used *speech-based* interaction as our primary mode of interaction. Half of the learners used speech as their primary mode of interaction. Additionally, *verbal attention catching mechanisms* such as questions, statements and learners expressing something made up more than half of the total ACMs coded in these episodes.

However, *non-verbal* language aspects evident in these episodes included *gaze* (specifically eye contact) and *gesture*. Half of the learners used gaze as their primary mode of interaction and both Mellony and myself used gestures as our secondary mode on interaction. Non-verbal ACMs such as *eye contact* and *gesture* made up almost a quarter of the total ACMs in these episodes. Radford, Edwards and Arzarello (2009) stated that different forms of gestures (such as pointing and emphasis) play “essential roles in communicating and thinking about mathematics” (p. 93) and they serve in generating and communicating meaning in mathematics. This resonated with what was noted in the presented episodes. A recent body of research (Beilock & Goldin-Meadow, 2010; Cook, Duffy, & Fenn, 2013;

Goldin-Meadow & Beilock, 2010; Novack, Congdon, Hemani-Lopez, & Goldin-Meadow, 2014) states that children can benefit from gesturing during mathematics and watching others gesture. Gesturing oneself while learning mathematics can lead to better understanding of concepts by introducing action into mental representations (Beilock & Goldin-Meadow, 2010).

> *The results provide the first evidence that gesture promotes transfer of knowledge better than direct action on objects and suggest that the beneficial effects gesture has on learning may reside in the features that differentiate it from action* (Novack et al., 2014, p. 1).

The above resonated strongly with my experience of working with these learners in the research clubs and from my analyses of the data. While this points to an important avenue of inquiry, and it has been useful to use other forms of social interaction as a filter in a broad sense to make these observations, it is beyond the scope of this study to explore this further, as it would shift focus from the key research questions. Additionally, as noted earlier, the video focused on learner interactions so not all mentor gestures were clearly captured. However, Roth (2001) and Radford, Edwards and Arzarello (2009) argued that there is a need for further research that focuses on the role of gestures and other modes of communication in the learning and teaching of mathematics. This is an avenue that I hope to pursue in my postdoctoral work.

Refining my interpretation of the ZPD

Throughout this study I have I stated that the ZPD as a symbolic space, does not exist prior to the learning activity. It is created through the social interactions with others during club activities and depends on the active contributions of the learners and the mentor. Presenting activities that are meaningful to the learner encourages the emergence of a ZPD. Activities that can be accomplished with assistance allow the learner agency to benefit and take advantage of the assistance from others. The data from this study points to the way in which the learning activity (as part of the ZPA) and the ethos of the club and the possible ways that the participants may interact in that moment (as part of the ZFM) are critical enablers of the ZPD.

This chapter and discussion has illustrated the emergence of a variety of ZPDs, ones that are different for each learner and which have emerged as a result of the combination of the activity, participators and context. My understanding of the ZPD for clubs in the wider context of the SANC project is grounded in my data and analysis and I now address the implications this has for speaking back to the theoretical concepts put forward in the literature review.

I propose that the ZPDs highlighted in this analysis could be described as both *relational* (Radford, 2010a) and *symbolic* (Meira & Lerman, 2001, 2009) and that they were *actively* co-constructed by the participants in the task-based interviews. Radford (2010) describes a relational ZPD as one that

> *is forged out of the interaction between students, and between the students and their teacher [..] The ZPD is not a static thing that belongs to one particular student but rather a social, complex system in motion* (Radford, 2010a, p. 116)

In this sense I argued that the ZPDs that emerged for these learners were as a result of the interactions between the participants in the interview (mentors and learners) and were both social and complex, they were connected to the context, the particular participants in the interview, the specific activity and the mediation offered by each of the mentors.

Meira and Lerman's (2001) notion of the ZPD as a symbolic space for interaction and communication where diverse communicative activities take place is also reflected in the ZPDs discussed here. Section 6.4 of this chapter showed an analysis of the diversity of communicative activities that took place across these three episodes, ranging from speech through to gaze, gesture and posture. This earlier analysis also showed that the learners actively contributed to the interactions in both verbal and non-verbal ways.

This active contribution is another key enabler for the creation of the ZPD, that of co-construction. Goos (2004) stated, "the active contribution of the learner is essential in negotiating the co-construction of the ZPD" (p. 263). Roth and Radford (2010) concur and maintain that participants are considered as actively involved in the "co-formation of an emerging intersubjective attunement that is made possible by language forms" (p. 305). When the learner actively contributes to the creation of the ZPD, mediation changes and involves structuring social interactions between learners by asking them to participate in mathematical thinking (Goos, 2004). Thus, while I have already illuminated this idea above I wish to conclude with it here.

The emergence of ZPDs in these task-based interviews seemed to arise from “in-the-moment micro-decisions” (term derived from Watson, 2007, p. 118) made by the mentors based on how attention was caught between the participants rather than being purposefully planned. Davydov argued that Vygotsky emphasised the activity of *all* participants in the learning and development process: “the child, the child's social milieu, and the teacher” (1995, p. 17). Davydov stated that for Vygotsky, the process is active in three ways. The child or learner is active, the teacher or other adult is active and the setting which they have constructed is also active. This resonated strongly with the data presented here where ZPDs emerged. I have argued that learners were active in different ways (directly or indirectly), and as Mellony and myself were active in the interviews and the context or setting in which we were working actively contributed to the learning space.

---- *END OF CHAPTER SIX* ----

CHAPTER 7 CLOSING

7.1 INTRODUCTION

In this chapter I summarise the empirical findings from the study, discuss theoretical and methodological contributions the study makes to the field, explore the implications of the study for my various roles in the SANC project and beyond and note the study's limitations.

In the context of two Grade 3 after school mathematics clubs, my research questions addressed:

1. How learners' mathematical proficiency levels evolved (if at all) over the period of participation in the maths club.
2. The nature of the mediation that enabled or constrained the emergence of ZPDs in club learners.

These questions reflect the dual nature of the research which was a theme running through the study. In Chapter Two, working with Sfard's (1998) metaphorical notions of acquisition and participation, I portrayed these two questions using the diagram in Figure 36 which reveals the relationship between the acquisition perspective foregrounded for question one and the participation perspective foregrounded for question two in this study.

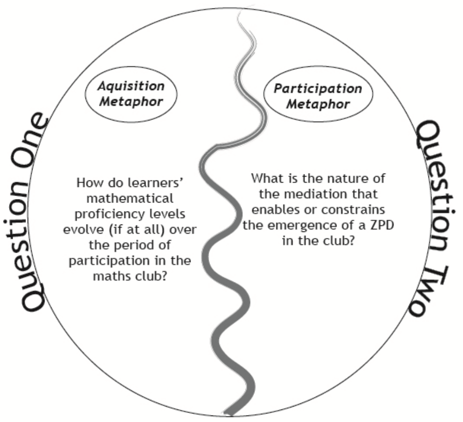


Figure 36: Dual nature of the research questions - revisited

Question one addressed *what learning* was acquired (or not) by the learners' period of participation in the club whilst the second question addressed the means by which this learning occurred by learners' period of participation in the club, in other words *how* learning occurred.

7.2 SUMMARY OF THE EMPIRICAL FINDINGS

In this section, I discuss how the findings from these two aspects come together to summarise the findings with regard to the overarching research aim. I approach the following discussion by looking at *how mathematical progression took place* and then at *what was learnt*.

HOW MATHEMATICAL PROGRESSION TOOK PLACE

The notion of a ZPD adopted for this study, is as a symbolic space where potential learning and development can take place. Learning does not always result in development but development is always lead or preceded by learning. The possibility for learning occurs *once* the ZPD comes into existence. In this respect, I discuss how the ZPDs came into existence for possible learning that occurred in this study.

A finding from this study was that: attention catching, mediation and 'flow[44]' were all mechanisms that enabled ZPDs to emerge and thus for learners to make progress in their mathematical proficiency. The study found that these mechanisms were supported by the club ethos and the specific activities promoted in the clubs. I discuss each of these in turn.

The findings from the second research question support Meira and Lerman's (2001, 2009) recently proposed notion that catching attention is key to the creation or emergence of a ZPD. In particular, my data showed that catching attention was one of the key mechanisms for sustaining a ZPD once it emerged and I additionally proposed the notion of *tuning in* or *tuning out* as a means of capturing attention (or not). Tuning in could be seen as periods of interaction where two (or more) participants continually adjust to each other in order to communicate mathematically. Tuning out could be seen when a participant was not willing and / or simply did not adjust or engage with another. A combination of catching attention and tuning in enabled the creation (emergence) and sustainment of a ZPD for club learners.

If attention was not caught, or participants did not tune in, then a ZPD did not emerge. In such instances, the data pointed to some cases in which the activity itself was useful in assisting a learner to be in the *flow*. This emergent notion of 'flow' plays a supporting role in the emergence of a ZPD but in it's own right, also serves a consolidating and confidence

[44] In Chapter Six I described *flow* as follows: in a learning process there cannot constantly be challenge and new learning. Sometimes learners need consolidation, opportunities to practice what they know and strengthen their fluency. Learners require the opportunity to build their confidence in being able to use, apply and communicate what they already know.

building function for learners who are not in a ZPD. Learners who are ‘in the flow’ are therefore not developing in terms of progressively developing new mathematical knowledge but are consolidating their existing mathematical knowledge and building their confidence.

This study also found that the *manner* in which the mediation was offered was important. The data revealed that mediation was often proffered as a result of learner speech-based offerings (but also included gestures and other modes of interaction), which had captured the mentors’ attention. As such the mentors’ mediation was intentional but also spontaneous, flexible, responsive and “in-the-moment” (a term derived from Watson, 2007, p. 118). In the episodes analysed, the mentors themselves were tuned in to what the learners were doing and saying and offered mediation based on this awareness of the learners offerings and interactions, both mathematical and non mathematical.

As has been argued in the earlier discussion, I suggested that the mediation begins with the careful selection of the activity, which is chosen with the purpose of catching the learners’ attention. Once initial attention is caught, mediation then becomes an awareness of the *direct*[45] contributions that learners make to the learning activity. This tuned-in awareness includes being mindful of when learners are engaged or disengaged. The analysis revealed that mentors drew on a wide range of mediational practices to draw learners back into the activity or to extend their mathematical understandings.

The study showed that once created, a ZPD can be sustained through a complex combination of attention catching sequences, continuous tuning in by participants, continued learner experience of success in problem solving, sustained engagement with the task on the learner’s part and responsive and flexible mediation.

The data revealed some commonalities across both case study sites with respect to these mechanisms. ZPDs emerged (albeit in different ways) for four of the six learners who participated in the task-based interviews. Reasons for the ZPDs not emerging for the two other learners were discussed in relation to their ways of engaging with the activities and their responses to the way mediation was offered. Furthermore, it was noted that mediation

[45] **Direct engagement** takes place when participants are communicating mathematically either verbally or by doing something mathematical. These connect with the coded ACMs of learners expressing themselves and mathematical action (writing, working out on paper, counting on fingers etc.).

was spontaneously offered in response to learner contributions (rather than being pre-planned) and the ZPDs that emerged in both clubs were sustained using a variety of common mechanisms mentioned above.

Some unique findings across the case study pairs of learners were revealed by the data. At the Luhlaza Primary club, one of the learners interviewed showed more tuning out than the other learners interviewed. As a result, this learner's story revealed that the nature of her participation was a key constraining factor in the creation of a ZPD for her and additionally highlighted that if learner agency is absent or restricted, then this can further constrain the emergence of a ZPD. Learners dependent on teacher instruction may lack the agency to make different contributions to mathematical interactions apart from calculating numerical answers and answering direct questions. This lack of agency means that certain types of mediation fail (such as that which focuses on clarification of learner thinking, restructuring of learner thinking and development of conceptual discourse) to be effective as the learner is unable to take advantage of the mediation. It was noted that the learner was perhaps more comfortable with 'traditional' mathematical practices that she encountered elsewhere.

I argued that the ethos promoted in the clubs encouraged the learners to *tune in* to each other. In club sessions, learners were often organised in pairs or groups and were encouraged to check each other's answers and to decide if they agreed with others or not. As mentor, I attempted to turn questions back to the group to consider and discuss. These practices encouraged the learners to listen to each mathematically and to share mathematical ideas, rather than simply waiting for their answer to be evaluated or to be told what the answer was. In this way the learners began to tune in to each other in both *direct* and *indirect* ways. These same practices were encouraged in the task-based interviews in order to mirror the club sessions. Thus the findings are connected to the Zone of Free Movement (ZFM) which I used as a way to describe how the learning environment supports learning in the clubs.

Of note is that the activities that were promoted in the clubs were informed by data gathered using the individually administered MP interviews and fluency assessments. In Vygotskian ZPD terms, these instruments revealed what the learners could do alone and what they could not yet do without assistance. Therefore, another contributing factor was the careful selection of activities promoted in the clubs, including games which focused on the learners' emerging mathematical proficiencies. Many activities (and particularly those for the task-based interviews) were selected deliberately to facilitate the emergence of ZPDs and thus assist in the development of mathematical proficiency and fluency in the club learners. Again, the findings feed into the club programme design for the broader SANC project under the Zone of Promoted Action (ZPA).

WHAT MATHEMATICS LEARNING OCCURRED?

If as Vygotsky suggested that the ZPD represents those processes that are in the course of maturing or are about to be developed, then *internalisation* marks the point at which these processes become part of the developmental achievement of the child (Vygotsky, 1978). In this respect, this study focused on what the club learners internalised (or learned) during their participation in these after school clubs.

The findings for research question one discussed in Chapter Five indicated that over the period of participation in the two case study clubs, mathematical proficiency levels showed improvement for all learners, indicating that some learning took place. Specifically, learners in both clubs made strong progress in the Learning Framework in Number (LFIN) aspects of *conceptual place value* and *early multiplication and division*; and in speed of completion and accuracy in specific fluency aspects such as *doubling, halving* and *adding and subtracting 10 and 100*.

The data from the two instruments used to assess learner mathematical proficiency (Mathematical Proficiency interviews and fluency assessments) showed learner progress over time from three perspectives. Firstly, the Mathematical Proficiency interview scores showed learner progress in answering interview tasks *accurately* by correctly answering more questions in the second interview than the first. Secondly learners showed progress by learners solving problems in more sophisticated and efficient ways as they progressed through LFIN levels or stages. Finally the methods used to solve the interview tasks provided qualitative data to describe *how* the learners solved problems and if these methods became more sophisticated over time.

I wove the broader notions of Kilpatrick et al.'s (2001) strands of mathematical proficiency, specifically with regard to *conceptual understanding, procedural fluency* and *adaptive reasoning* into the analysis of the Mathematical Proficiency interviews, looking for instances where learners displayed qualities of these strands. The findings revealed that learners across both clubs showed they were developing some degree of proficiency in each of these three strands.

7.3 THEORETICAL AND METHODOLOGICAL CONTRIBUTIONS

Whilst this study has provided an in-depth and methodological account of *how* mathematical progression occurred and the nature of mediation within the context of after school mathematics clubs, it also contributes methodologically and theoretically.

By using the Mathematical Proficiency interviews as a data collection instrument, I have been able to review the usefulness of the Maths Recovery programme interview approach for both research and practice purposes. Secondly, in using the LFIN framework as an analytic tool the study has shed some light on how this could be used in the Southern African context for both research purposes and in the classroom. Thirdly, I explored the option of generating *quantifiable* data from the Mathematical Proficiency interview scores and offered insight into how a scoring system could work for the Mathematical Proficiency interviews. These scores were used in this study as a means of presenting results from the Mathematical Proficiency interviews and allowed comparisons between the two clubs to be drawn. The creators of the Maths Recovery programme never intended for the assessment interview to result in a score. My study showed that using a combination of scores and the methods learners used to answer questions was useful for both planning of club activities and for analysis of progress made by learners through various levels or stages of the LFIN framework. This could make a useful and practical contribution to the body of work on the Maths Recovery programme here in South Africa and further afield as it is possibly an accessible way for teachers to deal with the data generated from Mathematical Proficiency interviews where there are large class numbers. As I have demonstrated in this study, the scores clearly reveal areas of weakness and strength and areas where further work needs to be done.

The development of a set of timed fluency activities, which included personal learner reflections on those activities were a useful complementary research and developmental tool for assessing the changing levels of learners' mathematical proficiency (specifically procedural fluency) over time. The activities provided me as a researcher and mentor, with a fast way of tracking, evaluating, encouraging and valuing learner progress but they also provided a mechanism for the learners to practice the fluency they were developing through other activities of the club and to self-assess their progress. More importantly, the use of learner reflections assisted learner buy-in and reduced the stress related to such timed assessments and alleviates, to some extent, any ethical unease with the use of such instruments.

Additionally I worked on operationalising Meira and Lerman's (2009) recently proposed attention catching notion. Meira and Lerman (2009) link the emergence of a ZPD as dependent on participants catching each other's attention. For this study I created my own analysis framework and used these attention-catching mechanisms (ACMs) to examine attention capturing sequences that occurred in the task-based interview video data.

From a *theoretical* perspective I have developed a categorisation framework that provides analytic structure to a review of the ZPD in educational literature. This enables the researcher and / or educator to locate their own use of the ZPD within this broader space and hence within their own theoretical and methodological framework. The framework proposes a way of looking at and making sense of the diversity of interpretations of the ZPD in the educational literature.

Secondly, I have illustrated how one might weave the broader notions of conceptual understanding, procedural fluency and adaptive reasoning from Kilpatrick et al.'s (2001) work into the analysis of the MP interviews. This in turn has shown how the strands could connect across the LFIN aspects allowing a richer description to emerge in the presentation and analysis of the data from a research study using these two frameworks. This link between the two frameworks is important for others who wish to work with both of these frameworks in mathematics education.

Thirdly, I examined the relationship between attention catching, mediation, the emergence of ZPDs and the relationship between the ZPD and an emergent zone called 'flow'. This study illustrated that these mechanisms enabled the emergence and sustainment of ZPDs which thus facilitated learners progress in mathematical proficiency over the period of participation in the after school maths club.

7.4 IMPLICATIONS OF THIS STUDY FOR MY VARIOUS ROLES IN THE SANC PROJECT AND BEYOND

This study has a number of implications for my own learning as a researcher and club facilitator, for the design of future after school clubs as well as for NICLE and broader teacher development. I explore each of these in turn.

For my own learning as researcher and club facilitator

Earlier in this thesis I spoke about my role in the clubs enabling an on-going, powerful reflective practice to develop between the club learning programme design, implementation and my own research. The habits of reflection and reflective practice have been a powerful part of my own learning throughout this study.

Consequently, as the study has progressed I have become progressively involved in the broader work of the SANC project. This has been enabled by using my learning from both the research process and development work in the clubs to feed into the project’s teacher development programme (NICLE), into club facilitator training and into supporting the project’s research community through post graduate supervision and lecturing. I have also had the opportunity to co-author several publications with Mellony Graven for peer-reviewed journals, conference proceedings, teacher focused journals and press articles, which has been both an enriching and enlightening process for me.

For future design of the clubs and sharing with future club facilitators

In Chapter Two I highlighted that research on and evaluation of OST programmes should document the characteristics of the OST programme and how the programme was implemented, as more evidence is needed of what characterises effective programmes. This point is important to this study in the context of the broader SANC project. During a recent conference presentation[46], I was asked what it is about the after school club model used for this study (and in the broader SANC project) that works. This study highlights a number of aspects that I argue are central to answering this question. I summarise the key points below using the zone theory framework. Although it is not necessarily feasible for others to work with the detail of the zone theory design elements of ZPA, ZFM, ZPD and my added zone of *flow*, I argue that this is a useful framework for explaining how the club programme is

[46] SAARSMTE 2014 (http://www.saarmste.org/conferences)

designed. The illustration below highlights the key elements of each zone for the club design.

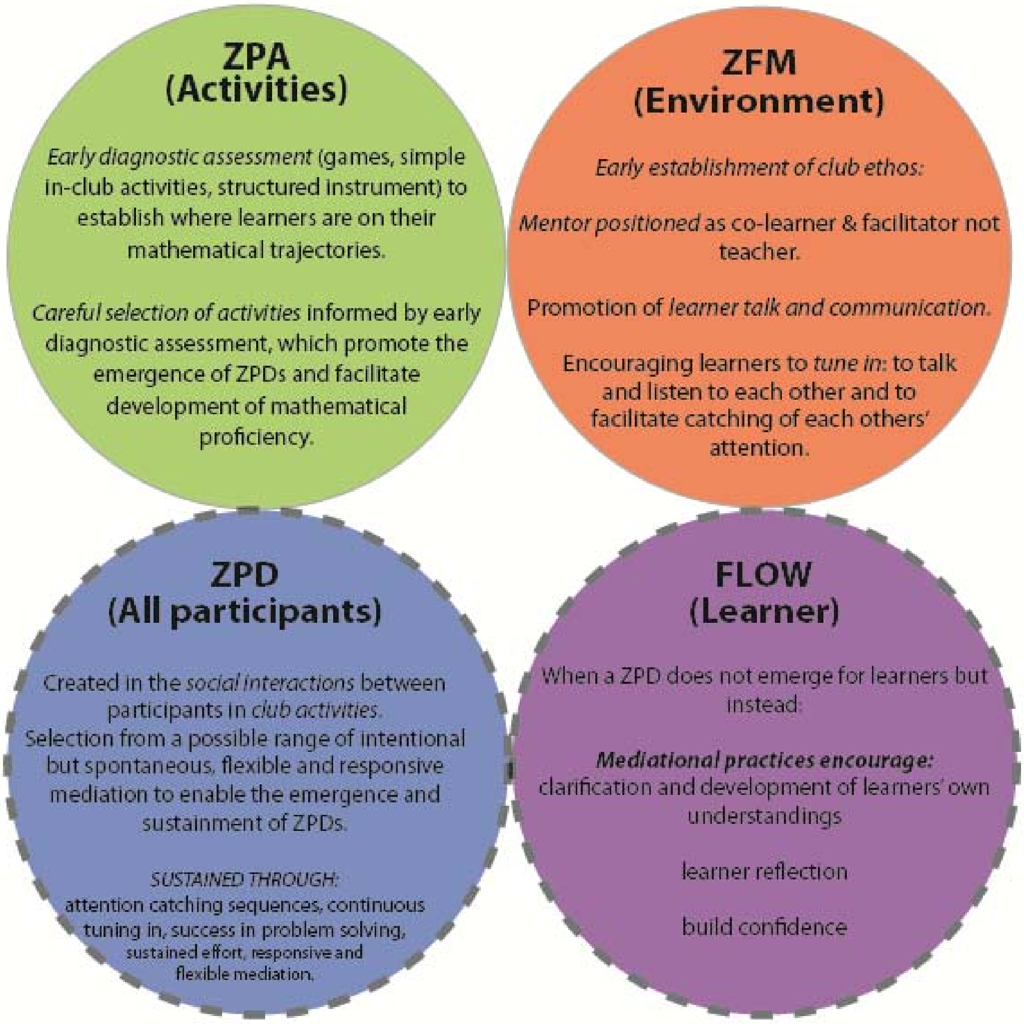


Figure 37: Key elements of each zone for club design

For NICLE and teacher development

I have stated previously that it is time-consuming to work with the MR programme one-to-one interviews and the LFIN profiling in their full form as intended by Wright et al. (2006). The interviews are however useful instruments for ascertaining where learners are in their mathematical learning trajectory. I would thus argue that using some parts of the interviews and the LFIN as standalone tools could be useful for educators. This study reveals that some aspects of the LFIN are particularly useful, for example the *early arithmetic strategies* and *early multiplication and division* learning progressions. These can help educators unpack the stages in which learners develop these proficiencies. Indeed, early multiplication and division are appearing as the focus in recent studies emanating from our SANC project students (see for example Mofu, 2013; Ndongeni, 2013).

For the duration of this research, myself and other SANC project team members who both run clubs and work directly with teachers have used the clubs as mini explorative spaces (or 'labs'). We have used the clubs to try out new activities and games, test theories, frameworks and assessments before sharing them with the teachers in the NICLE programme and with in-service teachers undertaking post-graduate mathematics courses (in which the SANC project is involved) at Rhodes University. Thus the clubs provide a safe space for building confidence and for trying new pedagogical approaches.

In one club that I currently mentor, the class teacher (who teaches grade 4 and 5 maths) has of her own free will participated in every session since the beginning of 2013. After the club, we reflect on learner progress and discuss if the activities and pedagogical approaches would work in her maths classes. She often gives me feedback on how these play out in the classroom and what changes she has made. This synergistic relationship is beneficial to both of us.

Local and national interest in our clubs is growing rapidly in a way neither Mellony Graven (who initiated them) nor myself anticipated. As the maths club coordinator, I have run various teacher workshops and conference workshops with our teacher facilitators on how to start and run clubs (Stott, Graven, Koliti, & Mase, 2013; Stott, Hewana, et al., 2013). We have also had requests from local NGOs, other universities, the Eastern Cape provincial Department of Education and regional districts to run workshops and to provide rationales for club funding. We have freely downloadable booklets and materials for starting clubs on our website (South African Numeracy Chair Project, 2013). This growing interest however comes with the challenge to engage more deeply with issues of sustainability and sphere of influence of our clubs. In recent conference papers (Graven & Stott, 2013; Stott & Graven, 2014) Mellony Graven and myself began exploring the issue of how our after school clubs have enabled ‘agents of change’ to emerge across four communities of participants, namely: learners, teachers/facilitators, teacher educators and researchers. This is an area which I hope to explore further in post-doctoral work.

7.5 LIMITATIONS OF THE STUDY

Generally a limitation of the case study research design is its lack of generalisability due to its small sample size. Indeed this is the case with this study. The multi site approach discussed in the methodology chapter goes some small way towards addressing this, as I have been able to compare and contrast findings across two clubs and different learners.

However others (for example Adler, 1996 in Graven, 2002a) talk rather of results being ‘generative’ rather than ‘generalisable’. Generative results indicate the extent to which they can produce or create similar results in other contexts. In this case, generative results would be the extent to which others might uncover similar findings in other clubs using the same methodology and programme design. In my context, those who benefit from this research are myself, other SANC project team members and members of the conference community in which I have participated and shared with during my study. More importantly, my increased involvement with other aspects of the SANC project and my continued involvement with after school clubs has meant that the findings and lessons learnt from this study have been tried out in other clubs and have been disseminated in various ways through published articles, conference papers, the project website and club facilitator and teacher development workshops. In this way the results are generative.

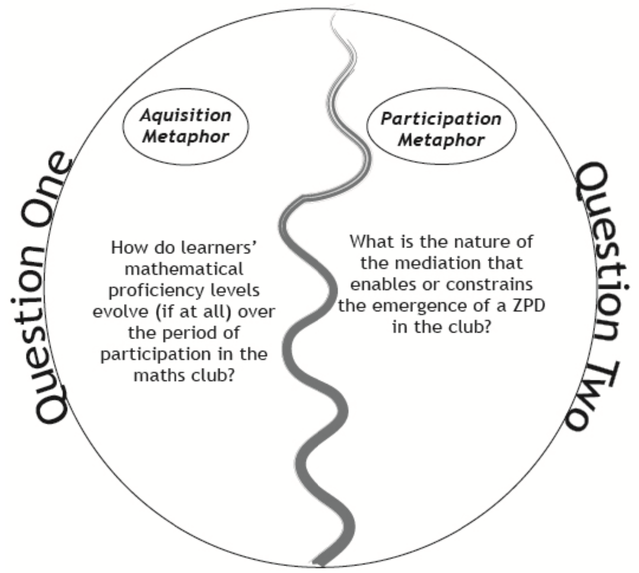
7.6 FURTHER RESEARCH

A most rewarding aspect of this research process has been its generation of avenues for further research that I am eager to begin. Particularly I would like to carry out further work on the relationship between attention catching mechanisms and gesturing using video data from other clubs that we have in the SANC project. The role of gesturing in learning and mediation was an unexpected finding that I have been unable to pursue fully. I also wish to explore mechanisms for ensuring the sustainability of clubs and their sphere of influence beyond the SANC project.

---- END OF CHAPTER SEVEN and THESIS ----

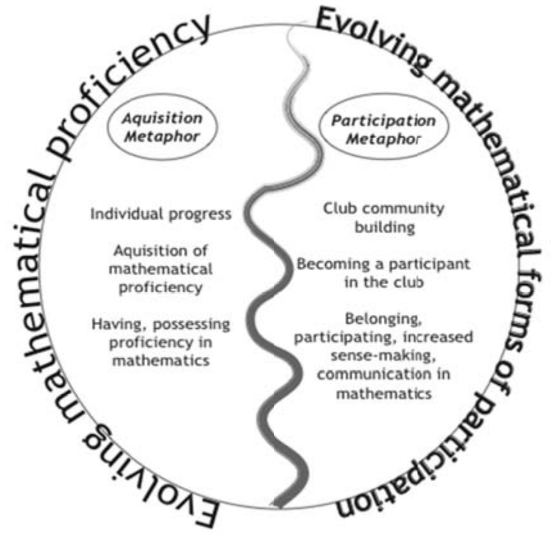
APPENDICES

APPENDIX A: Dual nature of the study diagrams

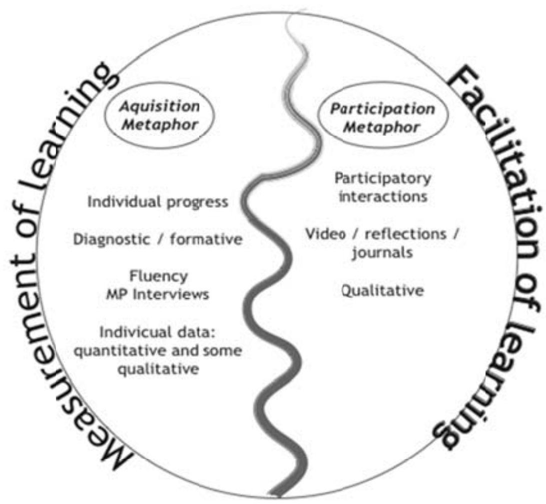


Research Questions

Theoretical Framework



Club Design



Data Collection / instruments: what evidence do I have?

END OF APPENDIX A

APPENDIX B: MP interview instrument

LEARNER & INTERVIEW INFORMATION		🕓 40 minutes	Date	
Surname		First name		
Club		Gender	Male ☐ Female ☐	Age
Mentor		Interviewer		

Instructions in **[bold brackets]**, what you say to the learner in *italics*
PLEASE WRITE IN BLACK OR BLUE PEN (NOT PENCIL)

PART ONE – Qs 1 to 11

Numeral identification, FNWS, BNWS, Counting by 10s & 100s, Place Value

Task 1: Numeral Identification W/CU

[Use number cards to show each number to learner. Tick if correctly identified]
Tell me the name of these numbers

6		*11*		*20*		*99*		*101*		*208*		*300*		*1025*		*½*		*¼*	

Comments:

Task 2: Number Representations A2/CU

[White card. Show 1 number line at a time] *Here is a number line. Tell me what number the arrow points to?*

	Wrongly positioned?	Correct
(a) 15		
(b) Approx. 90		

Comments:

Task 3: Forward counting number word sequences W/CU

[Ask orally] *Start counting in ones from ____ and I'll tell you when to stop.*

	Skipped numbers	Last no counted correctly
(a) 1 to 32		
(b) 48 to 61		
(c) 93 to 112		

Comments:

Task 4: Backward counting number word sequences W/PF

[Ask orally] Example: *Count backwards from 3. . .Three, two, one.*

Now count backwards in ones from ___ and keep going until I say stop.

	Skipped numbers	Last no counted correctly
(a) 10	•	
(b) 23 to 16	•	
(c) 72 to 67	•	

Comments:

Task 5: Number word before W/PF

[Use green number cards for each number] Example: *Which number comes just before 2? Now say the number that comes just before ___*

Note each answer

(a) 9		*(b) 11*	
(c) 20		*(d) 30*	
(e) 50		*(f) 100*	

Comments

Task 6: Number word after W/PF

[Use green number cards for each number] Example: *Which number comes just after 1? Now say the number that comes just after ___*

Note each answer

(a) 4		*(b) 19*	
(c) 25		*(d) 32*	
(e) 70		*(f) 99*	

Comments

Task 7: Sequencing numerals W/PF

[Show the green number cards face up in random order, asking the learner to identify each number as you put it out. Then say] *Can you place the cards in order? Start with the smallest number.*

	Note sequence learner laid cards out	Sequence correct
(a) Cards from 0 to 10		
(b) Cards from 46 to 55		

Comments:

Task 8: Perceptual counting W/PF

[Ask learner to place out counters for a & b. Note how learner counts these and the number counted]

	Counts in 1s?	Counts in multiple? Say which?
(a) Place out 13 counters for me		
(b) Place out 18 counters for me		

Comments:

Task 9: Counting with incrementing tens W/AR&CU

[Use pink strip cards. Show strip (a) then add others for steps b to e. Ask] *How many dots are there altogether?*

	Note Given Answer & How Answered	Correct?
(a) The ‘four dot’ strip		
(b) Add a ‘ten dot’ strip to the right	•	
(c) Add another 10 to make 24	•	
(d) Add another 20 to make 44	•	
(e) Add another 30 to make74	•	

Comments:

Task 10: Adding / subtracting with tens A2&3/PF

[Ask orally]

	Note Given Answer	Correct
(a) Add 10 to 92		
(b) Add 10 to 294		
(c) Take 10 away from 50		
(d) Take 10 away from 700		

Comments:

Task 11: Adding with incrementing hundreds A2&3/PF

[Ask orally]

	Note Given Answer	Correct
(a) Add 100 to 9		
(b) Add 100 to 932		
(c) Take 100 away from 400		
(d) Take 100 away from 634		

Comments:

END OF PART ONE

PART TWO – Qs 12 to 16

Early Arithmetic Strategies, Combining & Partitioning

Task 12: Horizontal sentences – Early Arithmetic Strategies W/AR

[Use blue sentence cards] *Tell me how you would work out the answer to:*

	Note Given Responses & How Answered	Correct
(a) 16 + 10 = ☐ *(b) So what is 16 + 9?*		
(c) 42 + 23 = ☐ *If correct ask, Do you have another way to work it out or check it?*		
(c) 43 – 15 = ☐ *Repeat the question above*		

Comments:

Task 13: Number Stories– Early Arithmetic Strategies A2&3/SC

[Ask orally] *I am going to read you some number stories. Answer the question at the end of the story.*

	Note Given Responses & How Answered	Correct
a) 12 people are on a bus and five get off. How many people are on the bus now?		
b) 22 people are on a bus. 13 are children. How many adults are there?		
c) 18 people were on a bus. 8 people get on and 3 get off. How many people are on the bus now?		

Comments:

Task 14: Number Stories– Early Arithmetic Strategies A2/SC

[Use pale yellow card with sums] *I am going to read you another number story. Here are some sums. Tell me which* ***sum*** *you would use to answer the question at the end of the story. I don't want the answer.*

	Given Answer	Correct
(a) There are 43 children in the class. 28 of the children are boys. How would you work out how many are girls?		

Comments:

Task 15: Non-count-by-ones – Early Arithmetic Strategies W/AR

[Use the orange calculation cards. Note how learner arrives at answers]

	Note Given Answers & How Answered	Correct?
(a) What is 9 + 3		
(b) Can you use that to help you work out 9 + 4		
(c) and 9 + 5		
(d) What is 7 – 5		
(e) Can you use that to help you work out 27 – 5		
(f) and 47 –		

Comments:

Task 16: Number combinations W/PF

[Ask orally]

	Note answers
I will say a number and you say the number that goes with it to make 5. *(a) 4* *(b) 0* *(c) 3*	
(d) Give me two numbers that add up to 10	
(e) Give me two other numbers adding up to 10	
(f) I have 7, how many more to make 10?	

Comments:

END OF PART TWO

PART THREE – Qs 17 to 24

Subitising, Multiplication and Division

Task 17: Visible items arranged in arrays – Subitising W/AR

[Use red dot cards. Show 1 at a time. Note how the learner counts & the given answer]

Tell me how many dots there are all together.

Given answer Counts in 1s/ multiples? Which multiple?

	Given answer			
(a) Show the 10 × 2 array of dots		1s	multiples	
(b) Show the 5 × 3 array of dots		1s	multiples	
(c) Turn (b) through 90 degrees		Recounts?	Instant answer?	

Comments:

Task 18: Visible items arranged in arrays – Subitising A2/AR

[Show the cake cards 1 at a time. Note how the learner counts & the given answer]

There are 5 cakes in each box. I am going to show you pictures of what the children bought for a short time. Look carefully and tell me how many cakes each one bought.

Given answer Counts in 1s / multiples? Which multiple?

	Given answer			
(a) Natasha		1s	multiples	
(b) Rajesh		1s	multiples	

Comments:

Task 19: Visible items arranged in arrays- Subitising A2/AR

[Show the apple cards 1 at a time. Note how the learner counts & the given answer]

There are 10 apples in a bag. I am going to show you pictures of what the children bought for a short time. Look carefully and tell me how many cakes each one bought.

Given answer Counts in 1s / multiples? Which multiple?

	Given answer			
(a) Dawn		1s	multiples	
(b) Gary		1s	multiples	

Comments:

Task 20: Equal grouping of visible items – Subitising and Multiplication W/CU

[Use orange circle cards. Place down four circles with three counters on each. Show the difference between circle and counter. Note how the learner counts & the given answer]

Given answer Counts in 1s / multiples? Which multiple?

	Given answer			
(a) *How many circles are there?*		1s	multiples	
(b) *How many counters in each circle?*		1s	multiples	
(c) *How many counters are there altogether?*		1s	multiples	

Comments:

Task 21: Equal grouping of visible items – Partition Division W/PF

[Place out a pile of 15 counters. Note how the learner counts & the given answer]

Given answer Works in 1s / multiples? Which multiple?

	Given answer	Works in 1s / multiples?		Which multiple?
(a) How many counters are there?		1s	multiples	
(b) Share them equally among 3 children.		1s	multiples	
(c) How many does each one get?		1s	multiples	

Comments:

Task 22: Equal grouping of visible items – Partition Division with RedistributionW/PI

[Place out a pile of 24 counters. Note how the learner counts & the given answer]

Given answer Works in 1s / multiples? Which multiple?

	Given answer	Works in 1s / multiples?		Which multiple?
(a) How many counters are there?		1s	multiples	
(b) Share them equally among 3 children.		1s	multiples	
(c) How many does each one get?		1s	multiples	
(d) Now share them equally among 4 children.				

Comments:

Task 23: A2/PF

[Ask orally] Given answer Correct

	Given answer	Correct
(a) Three lots of three makes (or three times three, equals)		
(b) Four lots of five makes (or four times five equals)		
(c) What are ten sets of four?		
(d) What are ten sets of 70?		

Comments:

Task 24: A2/CU

[Show white marbles card] *Jane and Peter play a game of marbles. Here is a picture of the marbles they use*

Given answer Correct

	Given answer	Correct
(a) Jane wins half of the marbles. How many marbles will she win?		
(b) Peter wins a quarter of the marbles. How many will he win?		

Comments:

END OF APPENDIX B

APPENDIX C: Fluency assessments instrument

Add and subtract to 10

Do as many of the addition sums as you can in 1 minute. One sum has been done for you.

Name						Date					
Add +	**2**	**4**	**1**	**0**	**3**	**Minus -**	**10**	**8**	**7**	**9**	**6**
3	**5**					**2**	**8**				
5						**4**					
4						**5**					
6						**3**					
7						**6**					

Add and subtract to 20

Do as many of the addition sums as you can in 2 minutes. One sum has been done for you.

Name:						**Date:**					
Add +	**2**	**7**	**8**	**9**	**5**	**Minus -**	**20**	**19**	**11**	**13**	**16**
5						**10**					
8						**8**	**12**				
6						**7**					
7						**6**					
9				**18**		**5**					

Doubles

Double each shaded number. One sum has been done for you.

Name						Date					
5		**4**		**2**	4	**6**		**7**		**8**	
15		**11**		**12**		**13**		**17**		**14**	
16		**18**		**32**		**25**		**24**		**44**	
75		**90**		**111**		**56**		**250**		**3100**	

Halves

Halve each shaded number. One sum has been done for you.

Name						Date					
6		**4**		**2**	1	**6**		**10**		**8**	
16		**14**		**12**		**16**		**22**		**24**	
100		**50**		**34**		**1000**		**500**		**26**	
11		**5**		**25**		**3**		**45**		**15**	

Add and subtract 10

Add or subtract 10 to each shaded number. Do as many as you can in 1 minute. One sum has been done for you.

Name						**Date**					
Add 10		**5**	15	**4**		**Minus 10**		**10**		**12**	2
2		**8**		**14**		**19**		**25**		**65**	
36		**42**		**99**		**98**		**108**		**205**	
102		**410**		**600**		**327**		**512**		**800**	

Add and subtract 100

Add or subtract 100 to each shaded number. Do as many as you can in 1 minute. One sum has been done for you

Name						**Date**					
Add 100		**5**	105	**4**		**Minus 100**		**100**		**102**	2
3				**13**		**109**		**125**		**165**	
36		**42**		**99**		**196**		**208**		**308**	
110		**420**		**600**		**452**		**547**		**1000**	

END OF APPENDIX C

APPENDIX D: Askew et al. (1997) test items background

Extract from Askew et al. (1997, pp. 104–111)

The basis of the design of the tiered tests was an aurally administered diagnostic numeracy test for whole classes aged 7-11 that had previously been developed at King's by Brenda Denvir (Denvir & Brown, 1987). This was itself adapted from a diagnostic interview that was the product of earlier research to identify a hierarchy of development of numeracy skills in low-attaining 7-9 year-olds (Denvir & Brown, 1986 a,b). An aural mode of testing was chosen where the teacher read out questions and pupils wrote down answers in specially designed answer books. This was done mainly to control the time pupils were allowed for each question; a wholly written test would not have enabled efficient methods to be so readily distinguished from more primitive time-consuming strategies based mainly on counting. Reading out questions was also more appropriate for younger children and weaker readers, enabled repetition where necessary, and maintained concentration for all groups. The skills assessed were:

Understanding of the number system

- Knowledge of the standard number word sequence
- Interpolation between numbers on a number line, with both whole number intervals and fractional intervals
- Knowledge of which numbers are ten more and ten
- less, a hundred more and a hundred less than a given number
- Effect of multiplying by 10 and identification of number of 10s in a number • Ordering of negative numbers in context
- Identification and ordering of fractions

Methods of computation

- Knowledge of addition and subtraction bonds
- Mental addition and subtraction of larger numbers
- Knowledge of multiplication bonds
- Multiplication and division: enumeration of items grouped in twos, fives, tens and hundreds (including representation to two decimal places)
- Use and calculation of percentages
- Calculation using ratios

Solving numerical problems

- Solution of complex addition, subtraction, multiplication and division word problems
- Solution of problems involving money
- Representation of complex word problems
- Identification of representation of complex word problems
- Appreciation of relationships between numbers and operations

END OF APPENDIX D

APPENDIX E: DEST scaffolding practices

Table 34: 12 Scaffolding practices[47] for effective teachers[48] [49]

1. **Excavating** - drawing out, digging, uncovering what is known, making it transparent
Teacher systematically questions to find out what students know or to make the known explicit. Teacher explores children’s understanding in a systematic way
2. **Modelling** - demonstrating, directing, instructing, showing, telling, funnelling, naming, labelling, explaining
Teacher shows students what to do and/or how to do it. Teacher instructs, explains, demonstrates, tells, offers behaviour for imitation
3. **Collaborating** - acting as an accomplice, co-learner/problem-solver, co-conspirator, negotiating
Teacher works interactively with students in-the-moment on a task to jointly achieve a solution. Teacher contributes ideas, tries things out, responds to suggestions of others, invites comments/opinions in what she/he is doing, accepts critique
4. **Guiding** - cuing, prompting, hinting, navigating, shepherding, encouraging, nudging
Teacher observes, listens, monitors students as they work, asks questions designed to help them see connections, and/or articulate generalisations
5. **Convince Me** - seeking explanation, justification, evidence; proving
Teacher actively seeks evidence, encourages students to be more specific. Teacher may act as if he/she doesn’t understand what students are saying, encourages students to explain, to provide/obtain data
6. **Noticing** - highlighting, drawing attention to, valuing, pointing to
Teacher draws students attention to particular feature without telling students what to see/notice (i.e. by careful questioning, rephrasing or gestures), encourages students to question their sensory experience
7. **Focusing** - coaching, tutoring, mentoring, flagging, redirecting, re-voicing, filtering
Teacher focuses on a specific gap (i.e. a concept, skill or strategy) that students need to progress. Teacher maintains a joint collective focus and provides an opportunity for students to bridge the gap themselves
8. **Probing** - clarifying, monitoring, checking
Teacher evaluates students understanding using a specific question/task designed to elicit a range of strategies, presses for clarification, identifies possible areas of need
9. **Orienting** - setting the scene, contextualising, reminding, alerting, recalling
Teacher sets the scene, poses a problem, establishes a context, invokes relevant prior knowledge and experience, provides a rationale (not necessarily at the beginning of the lesson, but at the beginning of a new task/idea)
10. **Reflecting / Reviewing** - sharing, reflecting, recounting, summarising, capturing, reinforcing, reflecting, rehearsing
Teacher orchestrates a recount of what was learnt, a sharing of ideas and strategies. This typically occurs during whole class share time at the end of a lesson where learning is made explicit, key strategies are articulated, valued and recorded
11. **Extending** - challenging, spring boarding, linking, connecting
Teacher sets significant challenge, uses open-ended questions to explore extent of children’s understanding, facilitate generalisations, provide a context for further learning
12. **Apprenticing** - inviting peer assistance, peer teaching, peer mentoring
Teacher provides opportunities for more learned peers to operate in a student-as-teacher capacity, endorses student/student interaction.

END OF APPENDIX E

[47] Source: http://www.eduweb.vic.gov.au/edulibrary/public/teachlearn/student/mathscontinuum/snmypraceffectiveteachers.pdf

[48] Kaulinge (2013) spoke of the need for ‘evaluating’ as a descriptor of several categories such as guiding, convince me, focusing, reflecting and noticing.

[49] This is the list of scaffolding practices published by the Victoria Department of Education and Early Childhood Development (2004). Note that I have numbered each category from 1 to 12. This numbering does not have any special significance in terms of importance or hierarchy.

APPENDIX F: Final mediating practice indicators

Table 35: Final scaffolding (mediating practices) analysis indicators used in this study

Anghileri Level & Description		**Sub category of scaffolding practice**	**Analysis Indicator**[50] (present continuous tense)	**Comments**
1	Environmental provisions	**Orienting**	*Setting the scene* * *Orienting* *	**Not in Anghileri but a way of introducing a problem, providing a rationale, context etc.**
		Emotive feedback	*Encouraging* § *Giving approval / praise* § *Valuing* *	
		Peer collaboration	*Inviting collaboration* *	Between learners
2a - Funnelling: leading question guide to a pre-determined solution				
2a	Funnelling Students thus need only to generate superficial procedures rather than meaningful mathematical strategies	**Showing and telling**	*Showing* § *Telling* § *Funnelling* § *Directing / re-directing* * *Demonstrating* *	Teacher in control, next step in plan, one-sided
		Teacher explaining	*Explaining* §	One-sided
2b and 2c - Focussing: joint attention on a critical point not yet understood, developing learners own understanding of mathematics through reviewing and restructuring				
2b	Reviewing: **Clarification of understanding** Refocus, give learners opportunity to develop their own understanding rather than relying on teacher to do so Interactions are intended to encourage reflection, clarification but not altering existing understandings.	**Looking, touching, verbalising**	*Asking for reflection on what is seen* § *Asking for verbalisation of observations* § *Asking for verbalisation of thinking* § *Seeking agreement / negotiating* *	
		Parallel modelling Alternative to 'show and tell'	*Modelling in parallel*	Create and solve a task that shares characteristics with learner's problem, learner retains ownership of their problem
		Prompting and probing	*Excavating* * *Prompting (lead toward predetermined solution)* § *Probing (expand on own thinking)* § *Clarifying* *	Closed Qs, cues for answer Focus on critical mathematics point so learners expand on own thinking
		Learners explain and justify	*Seeking explanation* § *Seeking justification* § *Seeking proof* *	Beyond verbalising, justifying promotes reflective thinking
		Interpreting students actions and	*Making actions explicit* § *Making talk explicit* §	Drawing explicit attention to strategies and actions,

[50] * Indicators drawn from DEST list § Indicators drawn from Anghileri 2006 text

Anghileri Level & Description		Sub category of scaffolding practice	Analysis Indicator [50] (present continuous tense)	Comments
		talk	*Reflecting on actions* § *Reflecting on talk* §	making key characteristics of a solution explicit
2c	Restructuring: **Taking understanding forward** Progressively introduce modification that make ideas more accessible, not only to establish contact with existing understanding but taking meanings forward	**Providing meaningful contexts to abstract situations**	*Establishing context* §	
		Simplifying the problem	*Simplifying the problem* §	Building progressive understanding to a larger problem
		Rephrasing learners talk	*Rephrasing learner talk* *Introducing mathematical language* § *Extending mathematical language* §	Highlighting processes involved in solutions Re-describing learner's efforts
		Negotiating meaning	*Promoting joint understanding* §	Co-operatively figuring things out, to determine what can be said and understood by all participants
3 Developing conceptual thinking				
3	**Developing conceptual thinking** Development of concepts through processes such as generalisation and abstraction	**Developing representational tools** Tools for thinking & notating thinking, for meaning making and structuring knowledge	*Using images §* *Using symbols §* *Using words §*	Visual imagery Formal and informal language
		Making connections	*Connecting ** *Linking **	
		Generating conceptual discourse While accepting a wide range of students explanations, teachers can indicate thinking strategies that are particularly valued, thus enabling students to become aware of more sophisticated forms of mathematical reasoning.	*Encouraging engagement in conceptual discourse* § *Encouraging process of generalisation* § *Encouraging process of abstraction* §	Using norms and standards

END OF APPENDIX F

APPENDIX G: Research question one - Additional MP interview and fluency assessment data

This appendix and the next (Appendix H) contains additional data for the MP interviews and fluency assessments presented in Chapter Five.

MP INTERVIEWS: ELMTREE PREP

Increases and decreases in scores

Table 36: MP interview: Matrix of score increases and decreases across aspects in Elmtree Prep

n=7	A	B	C	D	E
Same score	6	1		1	
Decrease in score	1	1		2	
Increase in score	0	5	7	4	7

ASPECT KEY:
A - *Number Words and Numerals*
B - *Structuring Numbers 1 to 20*
C - *Conceptual Place Value*
D - *Early arithmetic strategies*
E - *Early Multiplication and Division*

Aggregating and counting data for the whole club in this manner provided me with another way of looking at this data from a broad level. By counting the number of learners for each LFIN aspect that had increased or decreased scores across the two assessments (Table 36) or who had the same score for the two assessments, I can see a high-level picture of where progress has been made. The matrix shows that all seven learners improved in Aspects C and E in November. Four learners improved in Aspect D and five in Aspect B. A number of learner scores remained the same (6 in aspect A, 1 in B and D). In many cases this was due to the fact that the learners had already achieved 100% in the relevant aspect in March, thus leaving no room for improvement. This is illustrated particularly in Aspect A by Thembela, Zac, Zintle, Kholeka, Cebisa and Anathi.

Below I examine the March and November assessments separately.

Elmtree Prep: March MP Interview Results

Table 37: March MP interview scores for each aspect in Elmtree Prep

MARCH INTERVIEW	A	B	C	D	E
Anathi	100%	91%	77%	86%	90%
Cebisa	100%	94%	85%	93%	90%
Kholeka	100%	100%	92%	100%	90%
Nate	100%	91%	85%	86%	80%
Zac	100%	97%	92%	86%	85%
Thembela	100%	81%	77%	71%	85%
Zintle	100%	94%	69%	86%	85%
Averages	100%	92%	82%	87%	86%

ASPECT KEY:
A - *Number Words and Numerals*
B - *Structuring Numbers 1 to 20*
C - *Conceptual Place Value*
D - *Early arithmetic strategies*
E - *Early Multiplication and Division*

Table 38: MP interview score ranges for March in Elmtree Prep

% score range	No. of scores in the range
61% to 70%	1
71% to 80%	4
81% to 90%	13
91% to 100%	17
Total scores	35

Results for the March assessment (shown in Table 37) indicate the scores each club learner achieved for each LFIN aspect. Aspect A seems to indicate an area of strength since all learners are at 100%. All learners gained over 81% in Aspect B. A score range summary in Table 38 indicates that overall, the scores are not particularly low (69% is the lowest). There are five scores in the range 61% to 80% with the remainder split almost evenly between the upper two ranges (13 and 17 respectively).

Elmtree Prep: November Interview Results

Table 39: November MP interview scores for each aspect in Elmtree Prep

NOVEMBER INTERVIEW	A	B	C	D	E
Anathi	100%	100%	100%	93%	100%
Cebisa	100%	100%	100%	79%	95%
Kholeka	100%	100%	100%	100%	100%
Nate	88%	97%	100%	79%	100%
Zac	100%	100%	100%	100%	90%
Thembela	100%	100%	100%	93%	100%
Zintle	100%	91%	100%	100%	95%
Averages	98%	98%	100%	92%	97%

ASPECT KEY:
A - *Number Words and Numerals*
B - *Structuring Numbers 1 to 20*
C - *Conceptual Place Value*
D - *Early arithmetic strategies*
E - *Early Multiplication and Division*

The results in Table 39 above indicate the scores individual club learners achieved for each LFIN aspect in the November assessment. We see that all learners achieved 100% in Aspect C, which had been one of the areas of focus during club sessions. Although two learners decreased in scores for our other area of focus (Aspect D), the other 5 learners all increased pleasingly. The scores for Aspect E (the area of focus in the 3rd term) were also pleasing (over 90% for all learners) averaging 97% which was 11 percentage points up from the 85% average in March. Thembela achieved 100% in Aspect A. Nate and Zintle were the only two learners not to get 100% in Aspect A as they gave incorrect number word names for various numbers in their final interview.

Table 40 below indicates learner rankings after the March and November interviews respectively.

Table 40: MP Interviews: Learner ranks in March and November

Position	March Interview	November Interview
1	Kholeka	Kholeka
2	Cebisa / Zac	Thembela / Anathi
3	Zintle /Anathi	Zac
4	Nate	Zintle / Cebisa
5	Thembela	Nate

Additional data for Thembela

Table 41 below contrasts Thembela's scores from the MP interview in each LFIN aspect with the overall club averages for each LFIN aspect.

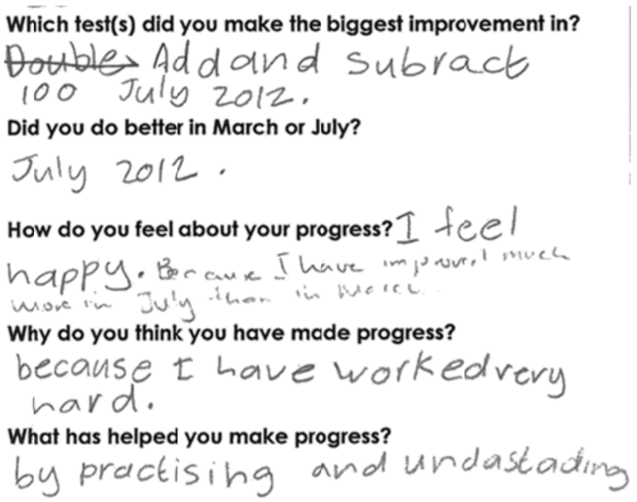
Table 41: MP Interviews: Thembela's March and November scores for each aspect

MP INTERVIEW	A	B	C	D	E
Thembela March Scores	100%	81%	77%	71%	85%
March Club Averages	100%	92%	82%	87%	86%
Thembela	100%	100%	100%	93%	100%

ASPECT KEY:
A - *Structuring Numbers 1 to 20*
B - *Number Words and Numerals*
C - *Conceptual Place Value*
D - *Early arithmetic strategies*
E - *Early Multiplication and Division*

November Scores					
November Club Averages	98%	98%	100%	92%	97%
Thembela % change	**0%**	**19%**	**23%**	**21%**	**15%**

Figure 38: Thembela's fluency activity reflections



Which test(s) did you make the biggest improvement in?
~~Double~~ Add and subract 100 July 2012.
Did you do better in March or July?
July 2012.
How do you feel about your progress? I feel happy. Because I have improved much more in July than in March.
Why do you think you have made progress?
because I have worked very hard.
What has helped you make progress?
by practising and undastading

Table 42: Thembela's progress in fluency activities

My Progress	How many did I finish?	How many did I get right?
Thembisa		
C) Doubling	**34**	**33**
March 2012	17	16
July 2012	17	17
D) Halving	**34**	**33**
March 2012	17	16
July 2012	17	17
E) Add & subtract 10	**24**	**23**
March 2012	7	7
July 2012	17	16
F) Add & subtract 100	**26**	**25**
March 2012	7	6
July 2012	19	19

MP INTERVIEWS: LUHLAZA PRIMARY

Increases and decreases in scores

The matrix in Table 43 shows the number of learners for each LFIN aspect that have increased or decreased scores across the two assessments or who have the same score for the two assessments, giving me a high-level picture of where progress has been made.

Table 43: MP interviews: matrix of score increases and decreases across aspects in Luhlaza Primary

n=4	A	B	C	D	E
Same score	1	2	0	1	0
Decrease in score	0	0	0	1	0
Increase in score	3	2	4	2	4

ASPECT KEY:
A - *Number Words and Numerals*
B - *Structuring Numbers 1 to 20*
C - *Conceptual Place Value*
D - *Early arithmetic strategies*
E - *Early Multiplication and Division*

All 4 learners improved in Aspects C and E in November. Three learners improved in Aspect A and two in Aspect B and D. Some learner scores remained the same. In almost every case, this was due to the fact that they had already achieved 100% in the relevant aspect in March (See Kuhle and Chebe).

Luhlaza Primary March Interview Results

Drilling down now to more detail about each LFIN aspect, I examine the percentage change for each learner for each Aspect from March to November I discuss these results in conjunction with Table 44 and Table 45 below.

Table 44: March MP interview scores for each aspect in Luhlaza Primary

MARCH INTERVIEW	A	B	C	D	E
Aphiwe	88%	91%	69%	93%	80%
Akhona	88%	81%	77%	64%	90%
Chebe	100%	91%	77%	79%	70%
Kuhle	100%	100%	92%	86%	90%
Averages	94%	91%	79%	80%	83%

ASPECT KEY:
A - *Number Words and Numerals*
B - *Structuring Numbers 1 to 20*
C - *Conceptual Place Value*
D - *Early arithmetic strategies*
E - *Early Multiplication and Division*

Results for the March assessment (shown in Table 44) indicate the scores each club learner achieved for each LFIN aspect. Aspects A and B seem to be strong areas with scores in the range 81% to 100%. Aspects C, D and E have more of a range of scores with the lowest being 64% and the highest being 93%.

Luhlaza Primary November Interview Results

Table 45: November MP interview scores for each aspect in Luhlaza Primary

NOVEMBER INTERVIEW	A	B	C	D	E
Aphiwe	100%	94%	92%	71%	90%
Akhona	100%	100%	100%	79%	95%
Chebe	100%	97%	92%	79%	90%
Kuhle	100%	100%	100%	100%	95%
Averages	100%	98%	96%	82%	93%

ASPECT KEY:
A - *Number Words and Numerals*
B - *Structuring Numbers 1 to 20*
C - *Conceptual Place Value*
D - *Early arithmetic strategies*
E - *Early Multiplication and Division*

These results (Table 45) indicate the scores each club learner achieved for each LFIN aspect in the November assessment. There is a pleasing 100% score for Aspect A for all learners in terms of recognising and sequencing numbers in the range 1 to 1000. Additionally Akhona has scored full marks in Aspects B and C and Kuhle in Aspects C and D. For Akhona these are substantial jumps of 12, 19 and 23 percentage points respectively. For Kuhle the jumps are more modest at 8 and 14 percentage points respectively. Aphiwe's biggest improvement is in Aspect C (23 percentage points) whilst Chebe's is in Aspect E (20 percentage points). As I argue in the Methodology chapter, a correct or incorrect answer to one question can translate into a large percentage change as illustrated in this set of results. I exemplify with some examples from these learners.

In March Akhona was unable to give a correct answer when working with 3-digit numbers such as '*take 10 away from 700'*, '*add 100 to 932'* or '*take 100 away from 634*'. In November, she was not only able to give answers but worked them out in mentally. In Kuhle's case, she was not able to calculate the correct answer to *43-15* in March, but was able to do so in November. I will talk later about the different methods she used to answer this question across the two assessments.

END OF APPENDIX G

APPENDIX H: Research question one – Full learner LFIN profiles

Table 46: Learner LFIN profile for Elmtree Prep: changes from March to November

ASPECTS & LEVELS															PROGRESSION	
															No. of Aspects where learner has	
Learner Name	Aspect A: Structuring Numbers 1 to 20 Levels 0 - 6 (Tasks 7 & 16)		Aspect B: Numeral Identification Levels 0 - 4 (Tasks 1 & 2)		Aspect B: FNWS Levels 0 - 5 (Tasks 3 & 6)		Aspect B: BNWS Levels 0 - 5 (Tasks 4 & 5)		Aspect C: Conceptual Place Value Levels 1 - 6 (Tasks 9, 10, 11)		Aspect D: Early arithmetic strategies Levels 0 - 5 (Tasks 12 to 15)		Aspect E: Early Multiplication & Division Levels 0 - 5 (Tasks 17 to 24)		moved 1 level or more	stayed at the same level
	MAR	NOV	MAR	NOV	MAR	NOV	MAR	NOV	MAR	NOV	MAR	NOV	MAR	NOV		
ANANATHI	4	4	3 No fractions or NL	4 All fractions & NL	5	5	4	4	2	3	3 to 4	3 to 4	1 to 2	4 to 5	3	4
CEBISA	4	4	3 All fractions / some NL	4 All fractions & NL	4 to 5	5	4	4	2 to 3	2 to 3	4	4	2 to 3	3 to 4	3	4
KHOLEKA	4	4	4 All fractions & NL	4 All fractions & NL	5	5	4	4	3	3	4	4 to 5	2 to 3	4 to 5	3	4
NATE	4	4	3 Some fractions / All NL	3 All fractions / All NL	4	5	4	4	2 to 3	3	4	4	2	3 to 4	4	3
ZAC	4	4	4 All fractions & Some NL	4 All fractions & NL	5	5	4	4	3	3	4 to 5	4 to 5	1 to 2	4 to 5	1	6
THEMBELA	4	4	3 Some fractions / No NL	4 All fractions & NL	3	5	4	4	2	3	2 to 3	3	1 to 2	1 to 2	4	3
ZINTLEE	4	4	4 No fractions & All NL	4 No fractions & Some NL	5	5	4	4	2	2 to 3	2 to 3	2 to 3	1 to 2	2 to 3	2	5

Table 47: Learner LFIN profile for Luhlaza Primary: changes from March to November

	ASPECTS & LEVELS														PROGRESSION	
															No. of Aspects where learner has	
	Aspect A: Structuring Numbers 1 to 20 Levels 0 - 6 (Tasks 7 & 16)		**Aspect B (i) Numeral Identification Levels 0 - 4 (Tasks 1 & 2)**		**Aspect B (ii) FNWS Levels 0 - 5 (Tasks 3 & 6)**		**Aspect B (iii) BNWS Levels 0 - 5 (Tasks 4 & 5)**		**Aspect C: Conceptual Place Value Levels 1 - 6 (Tasks 9, 10, 11)**		**Aspect D: Early arithmetic strategies Levels 0 - 5 (Tasks 12 to 15)**		**Aspect E: Early Multiplication & Division Levels 0 - 5 (Tasks 17 to 24)**		**moved 1 level or more**	**stayed at the same level**
	MAR	**NOV**	**MAR**	**NOV**	**MAR**	**NOV**	**MAR**	**NOV**	**MAR**	**NOV**	**MAR**	**NOV**	**MAR**	**NOV**		
KHULE	4	4	4 All fractions & NL	4 All fractions & NL	4	5	4	4	3	3	2	4 to 5	2 to 3	2 to 3	2	5
AKHONA	3 to 4	4	3 No fractions or NL	4 All fractions & NL	3 to 4	5	4	4	2	3	3	4	2	2	5	2
APHIWE	3 to 4	4	4 No fractions / some NL	4 All fractions / some NL	4 to 5	4 to 5	4	4	1	2	1 fingers	2 to 3	0 to 2	2 to 3	5	2
CHEBE	4	4	4 No fractions / some NL	4 All fractions / some NL	4 to 5	4 to 5	4	4	1 to 2	2 to 3	5	5	3	4	3	4

END OF APPENDIX H

APPENDIX I: Research question two - Full transcripts for Task 3 from task-based interviews

This appendix contains the full transcripts for task three from the task-based interviews undertaken and supplements the data and transcript extracts in Chapter Six.

Episode One: Elmtree Prep girls transcript

Time segment starts and ends	Transcript line number	Turn (indicates start & end of critical event)	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
12:43	1		DEBBIE	ACTION	***Places the activity sheet on the desk between the girls***	Activity		
	2		DEBBIE	SPEECH	Let's try the last thing, which is this thing. Ooh. Okay. Lovely.	M statement	L attention caught by activity (1)	Setting the scene (1)
	3	*1	ANATHI & THEMBELA	POSTURE / EXPRESSION / GAZE	***Thembela plays with her hair. Anathi leans in and draws in breath, aah and looks at the activity sheet***	Breath emphasis Posture		
	4		ANATHI	SPEECH	Wow!	Activity Exclamation		
12:47	5		DEBBIE	SPEECH	Have you seen one of these things before?	M question		Evaluating (1)
	6		ANATHI & THEMBELA	GAZE / SILENCE	***Debbie arranges activity sheet on the table Both girls are silent but looking at the activity***			
	7		DEBBIE	SPEECH	Have you ever seen anything like this?	M question		Evaluating (1)
	8	2	ANATHI	GESTURE	***Points pencil at the activity***		L attention caught by m question (5 & 7)	
	9		THEMBELA	POSTURE	***Leans in closer but still playing with her hair***			
	10		DEBBIE	GESTURE	***Touches the activity sheet***			
12:51	11		ANATHI & THEMBELA	GAZE	***Girls are still silent but both looking at the activity sheet***			
12:55	12		DEBBIE	SPEECH	Okay. All right. Um ***[pause]*** Let me give you some ideas then.	M question		Setting the scene (1) Explaining (2a)
	13		DEBBIE	GESTURE	***Points to the totals on the chart***	M gesture		
	14		ANATHI & THEMBELA	GAZE / SILENCE	***Girls are still silent but both looking at the activity sheet. Thembela still playing with her hair***			
12:55	15	3	DEBBIE	SPEECH	Where … if you … if you see something like this with a number at the end of the column or a number at the end of a row.	M question		
	16		DEBBIE	GESTURE	***Indicating rows and columns***			
13:02	17		THEMBELA	POSTURE	***Leans in closer to look at the chart***			
	18		DEBBIE	SPEECH	What do you think that number might mean?	M question		Probing (2b)
	19		THEMBELA	POSTURE	***Continues to look at the chart with hand on her cheek and then rests her chin on her pencil***			

Time segment starts and ends	Transcript line number	Turn (indicates start & end of critical event)	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
13:10	20		ANATHI	POSTURE	***Leans forward and says something inaudible***			
13:11	21	4	ANATHI	GESTURE	***Anathi points to chart with her pencil***	L gesture		
	22		ANATHI	EXPRESSION	***Anathi smiles at Debbie***			
	23		ANATHI	SPEECH	I think ***[speaking slowly]*** over here	L expressing something in direct response to M question (18)	L attention caught by m question (18)	
13:12	24		ANATHI	GESTURE	***Indicating the chart***			
13:16	25	5	DEBBIE	SPEECH	Okay… Anathi, carry on	M statement		Encouraging (1)
	26		DEBBIE	POSTURE / GESTURE	***Sitting back in her chair, gestures "continue" with her hand***			
	27		THEMBELA	GAZE	***Still looking at the chart***			
	28		ANATHI	EXPRESSION	***Covers her mouth with pencil and grins***			
	29			SPEECH	Yoh	Exclamation		
	30		DEBBIE & ANATHI	POSTURE / GAZE	***Anathi sits back, still looking at the chart*** ***Debbie starts to say something but Anathi interrupts***			
	31		ANATHI	SPEECH	But … when you get to twenty over here it's like I'm counting in fives over here	L expressing something in direct response to M question (18)	L attention caught by m question (18)	
	32		ANATHI	GESTURE	***pointing to the row of circles and the total 20***			
13:27	33	6	DEBBIE	SPEECH	Okay carry on, explain.	M statement	M attention caught by learner expressing something (23 to 32)	Evaluating (1) Valuing (1) Seeking explanation (2b)
	34		DEBBIE	GESTURE	***Debbie indicates 'continue' with her hand***	M gesture		
	35		DEBBIE	SPEECH	You're counting in fives. So count for me in fives.			Rephrasing learner talk (2c) Making actions explicit (2c)
	36		DEBBIE	GESTURE	***Debbie points to each circle in turn whilst Anathi counts***	M gesture		
	37		ANATHI	SPEECH	Five, ten, fifteen, twenty.			
	38		DEBBIE	SPEECH	Okay so what are you saying here Anathi? That this, if we count it in fives here this would equal twenty. So this is the total, or it's the sum of the row?	M statement M question		Rephrasing learner talk (2c) Making actions explicit (2) Clarifying (2b)
	39		THEMBELA	EXPRESSION / GAZE / POSTURE	***Smiles slightly, still looking at the chart and sits up straight***			
	40		DEBBIE	GESTURE	***Debbie indicates various totals on the chart***			
	41		ANATHI	POSTURE / GAZE	***Sits up straight and folds her arms on the table, looking at the chart and Debbie's gestures***			
	42		ANATHI	GESTURE	***Rubs her eye***			
	43		THEMBELA	GESTURE	***Plays with her hair again***			
	44	7	DEBBIE	SPEECH	So this twenty six is also adding up here	M statement		Clarifying (2b)
	45		ANATHI	SPEECH	Ja ***[at the same time]***	L statement		
	46		DEBBIE	SPEECH	to make twenty six	M statement		

Time segment starts and ends	Transcript line number	Turn (Indicates start & end of critical event)	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
13:46	47		THEMBELA	GAZE	***Looks at Debbie briefly***			
	48		DEBBIE	SPEECH	And this here, if you add these things up, will make?	M question		Prompting (2b)
	49		DEBBIE	GESTURE	***Debbie points to second row of the chart***	M gesture		
	50		THEMBELA	SPEECH	25?			
	51		THEMBELA	GAZE	***Looks at Debbie***			
13:49	52		DEBBIE	SPEECH	25. Okay? Okay, so what are these things?	M question		Clarifying (2b)
	53		DEBBIE	GESTURE	***Debbie indicates the symbols on the chart***	M gesture		
	54		ANATHI	SPEECH	Wait	L statement		
	55		ANATHI	POSTURE / GESTURE / GAZE	***Sits back, raises her hand in the air and lowers it again, all the while looking at the chart***			
	56		DEBBIE	SPEECH	Are they numbers?	M question		Prompting (2b)
	57		ANATHI & THEMBELA	SPEECH	No	L statement		
	58		DEBBIE	GESTURE	***Gestures with her hands***			
	59		ANATHI	POSTURE	***Crosses her arms and grins***			
	60		THEMBELA	GAZE / EXPRESSION	***Makes eye contact with Debbie and shakes her head***	Eye contact L->M		
	61		DEBBIE	SPEECH	What are they? This thing?	M statement		Prompting (2b)
	62		ANATHI & THEMBELA	SPEECH	A fly	L statement		
	63		DEBBIE	SPEECH	A club…	M statement		Prompting (2b)
	64		THEMBELA	SPEECH	A tree..	L statement		
	65		THEMBELA	GAZE	***Making eye contact with Debbie***	Eye contact L->M		
	66		DEBBIE	SPEECH	… or a tree. Whatever you want to call it. I don't mind. And this thing?	M statement		Prompting (2b)
	67		ANATHI & THEMBELA	SPEECH	A triangle, a circle.	L statement		
	68		DEBBIE	SPEECH	Okay. So what you have to imagine …	M statement		
	69		ANATHI & THEMBELA	GAZE	***Both girls looking at the chart***			
	70		ANATHI	EXPRESSION / POSTURE	***Anathi smiles and leans back with hand to her mouth and looks at Debbie whilst she is talking***		L attention caught by m statement (68)	Explaining (2a)
	71		DEBBIE	GESTURE	***indicating the shapes on the chart***			
	72	8	THEMBELA	GAZE	***Makes eye contact with Debbie***			
	73		DEBBIE	SPEECH	.. is that these shapes, they have also got a number attached.	M statement		
14:10	74		ANATHI	EXPRESSION	***Anathi smiles and breathes in***	Breath emphasis		
	75		ANATHI	SPEECH	Oooh, okaaay	L statement / exclamation	L attention caught by m statement (73)	
	76		ANATHI	EXPRESSION	***Anathi smiles broadly and leans back in her chair***			
	77		THEMBELA	POSTURE / GAZE	***Rests her chin in her hand and looks at the chart***			

Time segment starts and ends	Transcript line number	start & end of	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
	78		DEBBIE	SPEECH	So what did you …. Let's carry on with the thought here Anathi, that you had. What would the circle be?	M question		Asking for verbalisation of thinking (2b) Probing (2b)
	79	9	ANATHI	POSTURE	***Pulls her chair closer into the table***			
	80		THEMBELA	GAZE	***Looks at Debbie***	Eye contact L->M		
	81		ANATHI	SPEECH	I think ... The circles would be five.	L expressing something in direct response to M question (78)	L attention caught by m question (78)	
	82		DEBBIE	GESTURE	***Debbie gestures towards Thembela***	M gesture	M attention caught by learner expressing something (81)	
	83		THEMBELA	GAZE	***Brief eye contact with Debbie***	Eye contact L->M		
	84		DEBBIE	SPEECH	What do you think? Would you agree with that?	M question		Seeking agreement (2b)
	85	10	THEMBELA	POSTURE / GAZE / EXPRESSION	***Drops her hand from her face, looks at Debbie and nods***			
	86		THEMBELA	SPEECH	Yes.	L statement		
	87		THEMBELA	EXPRESSION / POSTURE	***Laughs a little, adjusts position in her chair***			
	88		DEBBIE	SPEECH	Okay, so let's put down on the paper here ..	M statement		Directing (2a) Using symbols (3)
	89		THEMBELA	SPEECH	Because …	L statement		
	90		DEBBIE	ACTION	***Debbie writes on paper***			Modelling (2b)
14:15	91		DEBBIE	SPEECH	Circles equals … ***[pauses]***	M statement		Using symbols (3)
	92		THEMBELA	GESTURE	***Gestures to the chart***			
	93		DEBBIE	SPEECH	Explain Thembela, Thembela, carry on	M statement		Seeking explanation (2b) Valuing (1)
	94	11	ANATHI	ACTION	***Writing in the paper***			
	95		THEMBELA	SPEECH	Because if the circles is added. If the answer is twenty then the circle add up to, must be 5	L expressing something direct response to M statement (93)	L attention caught by m statement (93)	
	96		THEMBELA	GESTURE / GAZE	***Thembela makes point by jabbing pencil and sitting back to make eye contact***	Eye contact L->M L gesture		
14:33	97	12	DEBBIE	SPEECH	Okay, super. So now you know that the circle is five.		M attention caught by L->M eye contact, l gesture (96)	Encouraging (1) Valuing (1) Making talk explicit (2b)

Time segment starts and ends	Transcript line number	Turn (indicates start & end of critical event)	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
	98		ANATHI	EXPRESSION	***Grins and breathes out***			
	99		DEBBIE	SPEECH	Now you've got to work out what the triangle is	M statement		
	100		ANATHI	EXPRESSION	***Anathi makes an exclamation***	Exclamation		
	101		DEBBIE	SPEECH	and what the tree is	M statement		
	102		THEMBELA	EXPRESSION / GAZE	***Shakes her head very briefly, still looking at the chart***			
	103		THEMBELA	SPEECH	Yoh	Exclamation		
	104		THEMBELA	POSTURE / EXPRESSION	***Sits back abruptly in her chair, with an expression of disbelief on her face***		L attention caught by m statement (99)	Orienting / refocusing (2b)
	105		ANATHI	GESTURE / EXPRESSION / POSTURE	***Covers her mouth with her hand, laughs and sits back in her chair***			
	106		DEBBIE	SPEECH	And the only clues that you've got are some totals. See what you get.	M statement		
	107		DEBBIE	GESTURE	***Indicates the totals on the chart***			
	108		ANATHI & THEMBELA	EXPRESSION / POSTURE	***Both learners exclaim and lean forward to look at chart and say some numbers***		L attention caught by m statement (106)	
	109		DEBBIE	SPEECH	Okay for this one, talk to each other	M statement		
	110		DEBBIE	GESTURE	***Gestures "together" with her pencil***	M gesture		
14:59	111		ANATHI & THEMBELA	GAZE / EXPRESSION	***Both girls look directly at Debbie and smile***	Eye contact L->M		Inviting collaboration (1)
	112		DEBBIE	SPEECH	Share ideas because you might all have different ideas	M statement		
	113		ANATHI & THEMBELA	EXPRESSION / GESTURE	***Both lean on the table and focus on the chart*** ***Thembela giggles and covers her face, Anathi laughs and looks upwards, both have pencils on chart***			
	114		ANATHI	SPEECH	Yoh	Exclamation		
15:11	115		ANATHI & THEMBELA	SPEECH	5…. 5…	L expressing something		
	116		ANATHI	GAZE / GESTURE / EXPRESSION	***Looks into the distance, then points at some shapes on the chart, shakes her head***	L expression		
15:23	117	13	DEBBIE	SPEECH	What were you doing there Anathi that says no it doesn't work?	M question	M attention caught directly by learner expressing something & l expression (115-116)	Asking for verbalisation of thinking (2b)
	118	14	ANATHI	SPEECH	I was going like five and then I thought these were the tens	L expressing something in	L attention caught	

Time segment starts and ends	Transcript line number	start & end of	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
						direct response to M question (117)	by m question (117)	
	119		ANATHI	GESTURE	***pointing to the shapes in the second row***			
	120		THEMBELA	GAZE / POSTURE	***continues to look at the chart with hand on her cheek***			
	121		ANATHI	SPEECH	but if I thought these were the tens it would be ten, twenty five, and then this would be ***[inaudible]***	L expressing something in direct response to M question (117)		
	122		DEBBIE	SPEECH	Okay, so we could say that the club is not a ten.	M statement	M attention caught by learner expressing something (118 & 121)	Reflecting on talk (2b) Making talk explicit (2b)
	123		DEBBIE	GESTURE	***reinforces statement with hand gesture***	M gesture		
*39:37	124	15	ANATHI & THEMBELA	GAZE	***both girls look at Debbie***	Eye contact L->M	L attention caught by m statement and m gesture (122-123)	
	125		ANATHI & THEMBELA	SPEECH	Ja	L statement		
	126		DEBBIE	SPEECH	Okay, so it's not as high as a ten. So that's good.	M statement		Making talk explicit (2b) Encouraging (1)
	127		DEBBIE	SPEECH	Remember yesterday we were playing that game	M statement		
	128		ANATHI & THEMBELA	GAZE	***both girls look at Debbie***	Eye contact L->M		
	129		DEBBIE	SPEECH	where we work things out	M statement		
	130		ANATHI	SPEECH	Yes			Making connections (3)
	131		ANATHI & THEMBELA	GAZE	***Both girls continue to look at Debbie***		L attention caught by m statement (127 & 129)	
16:00	132	16	ANATHI	EXPRESSION	***Anathi nods and laughs***			
	133		DEBBIE	SPEECH	and we work from what we know with our card game and with our clue game.	M statement		Encouraging engagement in conceptual discourse (3)
	134		THEMBELA	EXPRESSION / GAZE	***Thembela nods and glances very briefly at Anathi and then back at Debbie***			
	135		DEBBIE	SPEECH	Yeah. So we know the club is not a ten. Not that high. So we can now work out that it is going to be …?	M statement		Making talk explicit (2b) Prompting (2b)
	136		DEBBIE	GESTURE	***Debbie gestures "lower" with her hands***	M gesture		
	137		ANATHI	SPEECH	Lower …		L attention caught	

Time segment starts and ends	Transcript line number	Turn (indicates start & end of critical event)	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
16:01	138		ANATHI	GESTURE / GAZE	***Anathi gestures "lower" with her hand, whilst looking at Debbie***	L gesture	by m statement, m gesture (135-136)	
	139		THEMBELA	GESTURE	***Thembela points her pencil to chart as she thinks***	L gesture		
	140		ANATHI	EXPRESSION	***Anathi thinks and mouths something silently***			
	141		THEMBELA	EXPRESSION / POSTURE	***Thembela takes a breath, stretches and smiles***	Breath emphasis Posture		
16:19	142		THEMBELA	SPEECH	I think ***[slowly]*** the triangle is going to be eleven. That's what I think.	L expressing something		
	143	17	DEBBIE	SPEECH	And what would this be?	M question	M attention caught by learner expressing something (142)	Prompting (2b)
	144		THEMBELA	SPEECH	Four	L statement	L attention caught by m question (143)	
	145		THEMBELA	GESTURE / GAZE	***Thembela looks at Debbie and lays palm up on desk***	L gesture		
16:26	146		DEBBIE	SPEECH	Okay, So does that work? She said this is 4 and 4 is?	M question	M attention caught by l statement and by l gesture (144-145)	Seeking justification (2b) Promoting joint understanding (2c)
	147		ANATHI & THEMBELA	SPEECH	8			
	148		THEMBELA	SPEECH	plus 5, no… 16, 17, 18, 19, 20, 21	L expressing something		
	149		THEMBELA	ACTION	***Thembela counts briefly in 1s on fingers***			
	150		THEMBELA	SPEECH	.. Then			
	151	18	THEMBELA	EXPRESSION / GAZE	***Thembela shakes her head and looks at Debbie and then back at the paper***			
	152		THEMBELA	SPEECH	no…			
	153		ANATHI	GAZE	***Looks at Debbie***	Eye contact L->M		
16:40	154		DEBBIE	SPEECH	Okay…		M attention caught by learner expressing something (148-152)	Encouraging (1)
	155		THEMBELA	POSTURE / GAZE	***Leans back onto the table, looking at the chart***			
	156		ANATHI	EXPRESSION	***Anathi makes a face and grins***			
16:51	157		THEMBELA	SPEECH	It can't also be four because the club is 4.	L expressing something		
	158		THEMBELA	GAZE	***Makes eye contact with Debbie***	Eye contact L->M		

Time segment starts and ends	Transcript line number	start & end of	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
	159		DEBBIE	SPEECH	Okay, so if I tell you that each shape is a different number …	M statement	M attention caught by learner expressing something (157)	Simplifying the problem (2c)
	160		THEMBELA	SPEECH	Yes	L statement		
	161		ANATHI & THEMBELA	GAZE	***Both look at Debbie***			
	162		THEMBELA	SPEECH	Five. This can't be four because the club is already that.	L expressing something in direct response to M question (159)		
16:59	163		DEBBIE	POSTURE	***Debbie leans into the chart***			
	164		DEBBIE	SPEECH	So what you're saying at the moment is that the clubs maybe is equal to….?	M question	M attention caught by learner expressing something (162)	Making talk explicit (2b) Asking for verbalisation of thinking (2b)
	165		DEBBIE	ACTION	***Debbie records on Thembela's paper***	M action		Using symbols (3) Modelling (2b)
	166		ANATHI & THEMBELA	SPEECH	Four		L attention caught by m action, m question (164-165)	
	167		ANATHI & THEMBELA	GAZE	***Both watching Debbie record***			
	168		DEBBIE	SPEECH	Okay, test it. Oh, how can you test it though?	M statement / question		Seeking justification (2b) Probing (2b)
	169		THEMBELA	SPEECH	I said four plus five is nine, four…..	L expressing something		
	170		THEMBELA	GAZE	***Looks at Debbie***			
	171		DEBBIE	SPEECH	Okay, so you're saying four and four is eight and five is..?	M question		Making talk explicit (2b)
	172		ANATHI	ACTION	***Anathi meanwhile is writing something on her paper***			
	173	19	THEMBELA	SPEECH	Oh, wait, I said 4 and 4 is 8, right then plus a 5 is 21	L expressing something in direct response to M question (171)	L attention caught by m question (171)	
17:35	174		DEBBIE	SPEECH	Is it? 8 plus 5..?	M question		Prompting (2b)
	175		THEMBELA	GAZE / EXPRESSION	***Looks at Debbie and sighs***			
	176		ANATHI	GAZE / EXPRESSION	***Anathi repeats the sum and looks at Debbie with a quizzical look***	Eye contact L->M	L attention caught by m question (174)	
	177		THEMBELA	EXPRESSION	***Thembela gives a big sigh***			

Time segment starts and ends	Transcript line number	Turn (indicates start & end of critical event)	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
	178		ANATHI	SPEECH	13	L statement		
	179		THEMBELA	POSTURE	***Thembela lifts both hands above her head and makes an inaudible contribution***	L posture		
17:42	180		DEBBIE	SPEECH	So what would this be then? So you're saying the triangle maybe is………?	M question	M attention caught by l posture (179)	Probing (2b) Making talk explicit (2b)
	181		ANATHI & THEMBELA	SPEECH	Eleven	L statement		
	182		DEBBIE	ACTION	***Debbie records "11"***			
	183		THEMBELA	GAZE / EXPRESSION	***Looking at the chart and making a grimace***			
	184		DEBBIE	SPEECH	Okay how can we test it? Because we've got some triangles here. Will that work?	M question		Seeking justification (2b)
	185		THEMBELA	POSTURE / GESTURE	***Sits on edge of her chair and straightens her posture, pointing at the chart***			
	186		THEMBELA	SPEECH	Wooa. Wooa	L statement	L attention caught by m question (184)	
	187		ANATHI	POSTURE / GESTURE	***Anathi leans back in her chair & covers her mouth with her hand***			
	188		THEMBELA	SPEECH	5 plus 11	L expressing something in direct response to M question (184)		
	189		THEMBELA	POSTURE / GAZE	***Leans back in her chair, looking at Thembela's gestures***			
	190	20	ANATHI & THEMBELA	SPEECH	16			
	191		THEMBELA	SPEECH	plus another 5…			
	192		THEMBELA	GAZE	***Looks at Anathi***	Eye contact L->L		
	193		ANATHI	SPEECH	21	L expressing something in direct response to M question (184)		
	194		THEMBELA	SPEECH	plus another 11…. no it's not			
	195		THEMBELA	EXPRESSION / GAZE	***Thembela shakes her head emphatically and looks at Debbie, alters position in chair***	L expression Eye contact L->M L posture		
	196		ANATHI	EXPRESSION	***Anathi frowns***	Expression		
18:12	197	21	DEBBIE	SPEECH	Okay so the triangle can't be 11. So that one's not gonna work. All right.	M statement	M attention caught by L->M eye contact, l posture, l expression (195)	Making talk explicit (2b) Encouraging (1)
	198		DEBBIE	ACTION	***Debbie writes on paper***	M action		
	199		ANATHI	POSTURE / GAZE	***Crosses her arms and looks at the chart***			
	200		THEMBELA	GAZE	***Continues to look at the chart***			

Time segment starts and ends	Transcript line number	Turn (indicates start & end of critical event)	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
	201		THEMBELA	SPEECH	It can't be 11. 5, 10.	L expressing something		
	202		DEBBIE	SPEECH	10? Okay, good. I like that. What is the total here?	M question	M attention caught by learner expressing something (201)	Encouraging (1) Valuing (1) Prompting (2b)
	203	22	DEBBIE	GESTURE	***Debbie indicates the chart***	M gesture		
	204		ANATHI & THEMBELA	GAZE	***Girls look at the chart***			
	205		ANATHI & THEMBELA	SPEECH	26 ***[in unison]***	L statement	L attention caught by m question, m gesture (202-203)	
	206		ANATHI & THEMBELA	ACTION	***Both girls count the 2 circles***			
	207		ANATHI & THEMBELA	SPEECH	5, 10	L statement		
	208		THEMBELA	GESTURE	***Covers all but the last column with her hand***			
	209		DEBBIE	SPEECH	Can you just take your hand away so Mell can see..			
	210		MELLONY	SPEECH	No, no, no, keep your hand exactly where it was.. Because what you're doing is brilliant.			Encouraging (1)
18:20	211		THEMBELA	SPEECH	5, 10	L statement		
	212	23	THEMBELA	GESTURE	***Points to the 2 circles in final column of chart***			
	213		ANATHI	GAZE / EXPRESSION	***Anathi glances at Thembela and giggles***			
18:30	214		THEMBELA	POSTURE / EXPRESSION / GESTURE	***Thembela throws her head back and laughs aloud, then taps pencil against her mouth, as if thinking***	Posture		
	215		ANATHI	EXPRESSION	***laughs***			
	216		ANATHI & THEMBELA	ACTION / EXPRESSION	***Both calculate silently for a while, making exclamations occasionally***	Exclamation		
18:45	217		ANATHI	EXPRESSION	***Intake of breath and facial expression***			
	218		THEMBELA	SPEECH	Wait, wait, no it can't be a ten	L expressing something		
	219	24	THEMBELA	POSTURE / GAZE	***Thembela makes some gestures, looking at Debbie***	L gesture Eye contact L->M		
	220		ANATHI	EXPRESSION / GAZE	***Giggles again, also looking at Debbie***			
18:52	221	25*	DEBBIE	SPEECH	Okay so keep trying different numbers for this triangle.	M statement	M attention caught by learner expressing	Making actions explicit (2b) Making talk explicit (2b)

Time segment starts and ends	Transcript line number	Turn/ minutes start & end of critical event	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
							something, l gesture (218-219)	
	222		DEBBIE	ACTION / GESTURE	***Debbie lays her hand over Thembela's which covers all columns except last one on the activity grid***	M touch		
	223		DEBBIE	SPEECH	Because you've got, what have you said you've got here?	M question		Prompting (2b)
	224		DEBBIE	GESTURE	***Debbie indicates final column on chart***	M gesture		
	225		THEMBELA	SPEECH	5	L statement		
	226		THEMBELA	GESTURE	***Thembela points with her pencil***	L gesture		
	227		DEBBIE	SPEECH	5 and 5 make ten. You've got ten and are trying to get to?	M question		Prompting (2b)
	228		ANATHI	EXPRESSION	***Anathi has an intake of breath***	Breath emphasis		
	229		ANATHI	SPEECH	Aaah, I know, the triangles are 8	L expressing something	L attention caught by m touch, m question (222-223)	
19:01		26						
	230		ANATHI	EXPRESSION / POSTURE / GAZE	***Anathi points to the chart, laughs, leans forward and makes eye contact with Debbie***	Eye contact L->M		
	231		THEMBELA	GAZE	***looks at the chart***			
	232	27	DEBBIE	SPEECH	Tell me how you worked that out.	M statement	M attention caught by L->M eye contact and learner expressing something (229-230)	Asking for verbalisation of thinking (2b)
	233		DEBBIE	GESTURE	***Gestures towards Anathi***			
	234		ANATHI	SPEECH	I went like…	L expressing something in direct response to m statement (232)	L attention caught by m statement (232)	
	235		ANATHI	POSTURE	***Anathi makes a small movement of her shoulders***	Posture		
	236		THEMBELA	GAZE	***Continues to look at chart, watching Anathi's explanation, scratching the back of her neck***			
19:07	237	28	ANATHI	SPEECH	I counted in fives, and then I went like.. when you're count in 8's there's also a 26	L expressing something		
	238		ANATHI	GESTURE / GAZE / EXPRESSION	***Anathi gesturing with her hands, looks at Debbie, then frowns***	Eye contact L->M		
	239		ANATHI	SPEECH	Wait	L statement		
	240		ANATHI	POSTURE	***sits back in chair, rubs hands together and then puts hand on her face***	Posture		
	241		THEMBELA	GAZE	***Glances briefly at Anathi and then looks at Debbie***			

Time segment starts and ends	Transcript line number	Turn (indicates start & end of critical event)	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
	242		DEBBIE	SPEECH	Is there a 26? You’re so close, try, try …	M statement M question		Prompting (2b) Encouraging (1)
19:30	243	29	ANATHI	SPEECH	I went like 5 plus 5 is	L expressing something	L attention caught by m statement and by l expressing something (237, 239 & 242)	
	244		THEMBELA	POSTURE	***Thembela leans into the chart and joins in***	Posture		
	245		ANATHI & THEMBELA	SPEECH	10 and then plus 8 is 18	L expressing something		
	246		THEMBELA	GAZE	***Thembela looks at Debbie***	Eye contact L->M		
	247		ANATHI	SPEECH	plus another 8 is 26.	L expressing something		
	248		ANATHI	GAZE	***Anathi looks at Debbie. Both girls now looking at Debbie***	Eye contact L->M		
	249	30	DEBBIE	SPEECH	***[To Thembela]*** Do you agree with her?	Eye contact M->L M question	M attention caught by L->M eye contact and by learner expressing something (245-248)	Seeking agreement (2b)
	250		THEMBELA	SPEECH	Yeeeees	L expressing something in direct response to m question (249)	L attention caught by m question (249)	
	251		THEMBELA	POSTURE / EXPRESSION	***as she throws head backwards and laughs loudly***	Posture		
19:35	252		DEBBIE	SPEECH	So let’s put down that the triangle might be …?	M question		Making talk explicit (2b) Using symbols (3)
	253		DEBBIE	GESTURE	***Gestures towards the paper, indicating the girls should record what the triangle might be***			
	254		THEMBELA	ACTION / GAZE	***Records and looks at Debbie***	L action Eye contact L->M		
	255	31	THEMBELA	SPEECH	The triangle might be 18	L expressing something in direct response to m question (252)	L attention caught by m question (252)	
	256		DEBBIE	SPEECH	18?	M question		Prompting (2b)
	257		ANATHI	SPEECH	8	L statement		
	258		ANATHI	EXPRESSION/	***Anathi laughs merrily, with head thrown back***	Posture		

Time segment starts and ends	Transcript line number	Turn (indicates start & end of critical event)	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
				POSTURE				
	259		THEMBELA	SPEECH	Yoh	Exclamation		
	260		THEMBELA	ACTION	***Corrects her recording on paper and laughs***			
	261		DEBBIE	SPEECH	Okay what is it? 8? All right. Now test it this way	M statement M question		
	262		DEBBIE	GESTURE	***Debbie indicates the chart***	M gesture		Prompting (2b) Seeking justification (2b)
	263	32*	DEBBIE	SPEECH	Whichever way you want to see if you can find out if the triangle works.	M statement		
	264		THEMBELA	SPEECH	If this is 8, then this is 5 …. is 13, if circle is five, then this is 13, then clubs.. what will……?	L expressing something in direct response to m statement (263)	L attention caught by m gesture, m statement (262-263)	
	265		ANATHI	SPEECH	Wow! Look here			
	266		ANATHI	GESTURE	***Indicates the empty total box at end of 1st row***			
19:57	267	33	ANATHI & THEMBELA	EXPRESSION / POSTURE	***plenty of laughter and rocking in the chairs from both girls***	Expression Posture		
	268		ANATHI	SPEECH	Let's finish this one	L expressing something		
	269		DEBBIE	SPEECH	Carry on. Yes, okay, what was your thought?	M question	M attention caught by learner expressing something (268)	Valuing (1) Asking for verbalisation of thinking (2b)
20:10	270		DEBBIE	GAZE	***to Anathi***	Eye contact M->L		
	271		DEBBIE	SPEECH	You said 5 plus 8 is?	M question		Prompting (2b)
	272	34	THEMBELA	SPEECH	13	L statement		
	273		DEBBIE	GESTURE	***Gestures towards the paper***			
	274		ANATHI & THEMBELA	ACTION	***Both girls write***			
	275		THEMBELA	ACTION / SPEECH	5 +6=13 ***[Whilst writing]*** 8 plus 5 is 13	L expressing something		
	276		DEBBIE	SPEECH	Okay, 13. So write that down so you don't have to keep it in your mind. All right? And what are you trying to get to?	M statement M question	M attention caught by learner expressing something (275)	Modelling (2b) Using symbols (3) Prompting (2b)
20:11	277	35	ANATHI & THEMBELA	SPEECH	25	L statement		
	278		DEBBIE	SPEECH	Okay, see if you can work it out.	M statement		Making actions explicit (2b)

Time segment starts and ends	Transcript line number	start & end of	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
								Valuing (1)
20:29	279		THEMBELA	SPEECH	A fly is..	L statement		
	280		THEMBELA	GESTURE / EXPRESSION	***Thembela flings back her arms and hits her hand with her pencil, then shakes her head***	Posture Expression		
	281		THEMBELA	SPEECH	The 2 flies, it would be double that…	L expressing something		
	282		THEMBELA	GAZE / GESTURE	***looking at Debbie and gesticulating***	Eye contact L->M L gesture		
	283		DEBBIE	SPEECH	The two flies … the flies will all be the same number.	M statement	M attention caught by l expression something, L->M eye contact, l gesture (281-282)	Reflecting on talk (2b) Promoting joint understanding (2c)
	284		THEMBELA	SPEECH	Yes	L statement		
20:43	285		THEMBELA	GAZE	***Making eye contact with Debbie***			
	286		DEBBIE	SPEECH	The circles are always 5. The triangles you say are 8. So, you've got to find out if these are going to be the same number	M statement		Reflecting on talk (2b) Promoting joint understanding (2c)
	287		ANATHI	EXPRESSION	***Anathi has an intake of breath***	Breath emphasis Exclamation		
	288		ANATHI	SPEECH	Ooooh,	Expression		
	289		DEBBIE	SPEECH	because all the flies are going to be the same number	M statement		Explaining (2a)
	290	36	ANATHI	GAZE / EXPRESSION	***Anathi looks at Debbie and smiles***	Eye contact L->M	L attention caught by m statement (289)	
	291		THEMBELA	SPEECH	I just thought it can't be because it will be double those	L expressing something		
	292		THEMBELA	GESTURE / GAZE	***Thembela indicates something on the chart and looks at Debbie***	L gesture Eye contact L->M		
	293		DEBBIE	SPEECH	Too big. Okay	M statement	M attention caught by l expressing something, gesture, L->M eye contact (291-292)	Reflecting on talk (2b) Valuing (1)
	294		THEMBELA	POSTURE	***Arms above head, leaning back***			
	295		ANATHI	POSTURE	***Arms crossed on the table, looking at the chart***			
	296		ANATHI & THEMBELA	EXPRESSION	***Both exclaiming***			
20:58	297	37*	ANATHI	SPEECH	Eish, hey hey. You see what I did?	L exclamation		

Time segment starts and ends	Transcript line number	Turn (indicates start & end of critical event)	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
						L expressing something		
	298		ANATHI	GAZE	***Looking at Debbie whilst she talks***	Eye contact L->M		
	299		THEMBELA	GAZE / EXPRESSION	***Looking at the paper and smiling softly***			
	300		ANATHI	SPEECH	I went like … I went … 13	L expressing something	L attention caught by l exclamation, l expressing something, L->M eye contact (297-298)	
	301		ANATHI	GESTURE	***tapping the circle and triangle on the 2nd row of the chart***	L gesture		
	302		ANATHI	SPEECH	and then I went 13,	L expressing something		
	303		ANATHI	ACTION	***starts counting on fingers***			
	304		ANATHI	SPEECH	14, 15, 16, 17, 18,19, 20, 21, 22, 23, 24, 25.	L expressing something		
	305		THEMBELA	POSTURE / GAZE	***Sitting back in her chair, with hand on her shoulder. When Anathi says 25, she looks at Debbie***			
21:14	306		ANATHI	SPEECH	Aaah! ***(in excited tone)***	L exclamation		
	307			POSTURE	***Anathi looks at Debbie, throws back arms and leans back in her chair***	L posture Eye contact L->M		
	308	38	DEBBIE	SPEECH	What's the difference? What is the difference there?	M question	M attention caught by l exclamation, l posture, L->M eye contact (306-307)	Introducing mathematical language (2c) Making actions explicit (2b)
	309		ANATHI	GAZE	***Looks at the chart, pauses as if thinking***			
	310		DEBBIE	GESTURE	***Debbie gestures with her pencil to Anathi***	M gesture		
	311		ANATHI	GESTURE / GAZE	***Anathi covers her mouth with her hand, then continues to look at Debbie***	L gesture		
	312		DEBBIE	SPEECH	What did you count up there? You counted it up. What is the difference between thirteen and twenty five? Was?	M question		Probing (2b) Introducing mathematical language (2c)
	313		THEMBELA	POSTURE / GAZE	***Still sitting back in her chair, brief eye contact with Debbie***			
	314	39	ANATHI	POSTURE / ACTION	***Anathi sits forward in her chair again, looks at Debbie, wipes her face with her hands***	Eye contact L->M		
	315		THEMBELA	GAZE	***Thembela looks at Anathi***	Eye contact L->L		
	316		THEMBELA	POSTURE	***Thembela closes her eyes as if thinking***			
	317		DEBBIE	SPEECH	Do it again for me. You did 13 …	M statement		Making actions explicit (2b)
	318		ANATHI & DEBBIE	ACTION	***Anathi counts on her fingers and Debbie mimics her action***	L action	L attention caught by m statement (317)	

Time segment starts and ends	Transcript line number	Turn (indicates start & end of critical event)	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
	319		ANATHI	SPEECH	13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25 … Ooooh	L expressing something		
	320		ANATHI	POSTURE / GAZE	***Anathi flings hands up again and looks at Debbie***	L posture Eye contact L->M		
	321		ANATHI	SPEECH	Yoh, 6	L exclamation		
	322		DEBBIE	SPEECH	Was?	M question	M attention caught by l posture, by l exclamation and by expressing something (319-321)	Prompting (2b)
	323		ANATHI	SPEECH	12	L statement		
	324		DEBBIE	SPEECH	Okay so she counted up 12 to get to what?	M question		Making actions explicit (2b) Introducing mathematical language (2c)
	325		ANATHI	POSTURE	***Anathi pulls chair up to the table***	Posture		
21:36	326	40	THEMBELA	POSTURE	***Thembela sits back in chair, nods***	Posture		
	327		ANATHI & THEMBELA	SPEECH	25	L statement	L attention caught by m question (324)	
	328		ANATHI	ACTION / GAZE	***Anathi starts writing on her paper and looks at Debbie***	L action Eye contact L->M		
	329		DEBBIE	SPEECH	Okay, now so what do you think the club is?	M question	M attention caught by l statement, l action, L->M eye contact (327-328)	Probing (2b)
	330		THEMBELA	GESTURE / ACTION / POSTURE	***Shakes her pencil and starts writing on her paper, leaning back into the table***			
	331	41	ANATHI & THEMBELA	SPEECH	6, the club is 6	L statement	L attention caught by m question (329)	
	332		ANATHI	GAZE	***Continues to look at Debbie***	Eye contact L->M		
	333		ANATHI & THEMBELA	ACTION	 ***both write on paper: "club=6"***	L action		
21:39	334	42	DEBBIE	SPEECH	Why?	M question		Seeking justification (2b)
	335		ANATHI	SPEECH	Ooooh…	Exclamation	L attention caught	

Time segment starts and ends	Transcript line number	Turn (indicates start & end of critical event)	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
	336		ANATHI	POSTURE / GESTURE	***Anathi claps her hands, does a little dance in the chair, leans back into the table and taps the chart with her pencil***	Posture	by m question (334)	
	337		ANATHI	SPEECH	because half of the twelve is 16	L expressing something in direct response to m question (334)		
	338		ANATHI	GESTURE	***Tapping the chart with her pencil***			
	339		ANATHI	POSTURE / GESTURE	***Anathi sits back in chair, makes an expansive hand gesture and looks at Debbie***	L gesture L posture Eye contact L->M		
21:44	340	43	DEBBIE	SPEECH	Aaaah. ***[rising intonation]*** Okay, alright so we're saying this is a...?	M question	M attention caught by l gesture, l posture and by expressing something (337 & 339)	Establishing joint understanding (2c)
	341		DEBBIE / ANATHI & THEMBELA		6	L statement		
	342		THEMBELA	GAZE	***Thembela looks at Debbie***	Eye contact L->M		
	343		DEBBIE	GESTURE	***Debbie points to the club on Thembela's paper***	M gesture		Using symbols (3)
	344	44	DEBBIE	SPEECH	Let's try it. Let's add up another one and see if…	M statement		Seeking justification (2b)
	345		DEBBIE	GESTURE	***indicates another row on the chart***			
	346		THEMBELA	SPEECH	Ok	L statement		
	347		ANATHI	ACTION	***Anathi looks at her workings***			
	348		DEBBIE	SPEECH	Just do either one column or one row. You can choose which one	M statement		Directing (2a)
22:01	349		ANATHI	SPEECH	Let's start with this one.	L statement	L attention caught by m statement / m gesture (343-344)	
	350	45	ANATHI	GESTURE	***Anathi points to final row of the grid***	L gesture		
	351		ANATHI	SPEECH	16, 17, 18 … 16 plus..			
	352		THEMBELA	SPEECH	16 plus 12 ….	L expressing something	L attention caught by l statement / l gesture (349-350)	
	353		ANATHI	SPEECH	28. I think so.	L expressing something		
	354		ANATHI	GAZE	***Anathi looks briefly at Debbie***	Eye contact L->M		
22:10	355	46*	DEBBIE	SPEECH	So you reckon that one is 28?	M question	M attention caught	Making talk explicit (2b)

Time segment starts and ends	Transcript line number	start & end of	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
							by learner expressing something (352-353)	Reflecting on learner talk (2b)
	356		DEBBIE	GESTURE	***Debbie indicates a total on the chart***			
	357		THEMBELA	ACTION	***Thembela writes 28 in the total box on the chart***	L action	L attention caught by m question (355)	
	358		DEBBIE	SPEECH	Okay, cool. Leave it that's cool. I think you've solved it. What is this for you?	M question		Encouraging (1) Establishing joint understanding (2c)
	359		DEBBIE	GESTURE	***Debbie points to shapes on the chart***	M gesture		
	360	47	DEBBIE	SPEECH	Is it? 4? Or did we say…	M statement		Establishing joint understanding (2c)
	361		ANATHI	SPEECH	No. 6.	L statement	L attention caught by m question / m gesture (358-360)	
22:25	362		DEBBIE	SPEECH	You've written it there. Okay. Well done.	M statement		Making actions explicit (2b) Encouraging (1)

End of Episode One

Episode Two: Elmtree Prep boys transcript

Time segment starts and ends	Transcript line number	(* indicates start & end of	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
33:26	1		MELLONY	SPEECH	Okay, so guys what do you think is happening here? What do you think the question is?	Activity		Orienting (1) setting the scene (1)
	2		NATE & ZAC	EXPRESSION / GAZE	***Nate grins, both boys look at the activity***		L attention caught by activity (1)	
	3	1	NATE	GESTURE / GAZE	***Taps his pencil on his thigh, looking at the activity***			
	4		MELLONY	SPEECH	Have you ever seen anything like this before?	M question		Excavating (2b)
33:39	5		NATE & ZAC	SPEECH	No			
	6		NATE	EXPRESSION	***Nate shakes his head***			
	7		MELLONY	SPEECH	Okay, have you ever seen grids and then there's a number at the end?	M question		Excavating (2b)
	8		MELLONY	GAZE / GESTURE	***Looks at Zac, pointing to a total on the grid***			
	9		NATE	GAZE	***Nate looks at Zac***			
	10		MELLONY	GAZE	***Looks at Nate***	Eye contact M->L		
	11		ZAC	INAUDIBLE	***Zac says something inaudible***			
	12		MELLONY	SPEECH	Okay, and usually, what's the number on the end showing?	M question		Funnelling (2a)
	13		MELLONY	GAZE	***Continues to look at Zac***			
	14		NATE	EXPRESSION / GAZE	***Grinning looks at Mellony and at Zac***			
33:54	15		ZAC	EXPRESSION / GAZE	***Zac appears to be thinking about something, but remains silent.***	Eye contact L->M		
	16		MELLONY	GAZE	***Turns to look at Nate***			
	17	2	NATE & ZAC	EXPRESSION	***Both boys are grinning but silent***			
	18		MELLONY	SPEECH	You've seen something like this before? What do the numbers on the end usually show?	M question		Funnelling (2a)
	19		NATE	GAZE / EXPRESSION / POSTURE	***Nate glances at Zac again, grins and leans back in his chair***	Eye contact L->L		
	20		ZAC	UNCLEAR	***Zac says something inaudible***		L attention caught by m question (18)	
34:10	21		NATE & ZAC	SPEECH	No we don't know ***[very softly]***			
	22		MELLONY	SPEECH	Okay, the numbers on the end show the total if we add up	M statement		Telling (2a)
	23		MELLONY	GESTURE / GAZE	***Mellony indicates shapes in the grid and looks at each boy in turn***			
	24		ZAC	POSTURE / GAZE	***Leans into the table, looking at the chart, eyes are downcast***			
	25		NATE	ACTION	***Nate sitting back in his chair, rubs his head with his hands***			
	26		MELLONY	GAZE	***Mellony looks at Zac***	Eye contact M->L		
	27		MELLONY	SPEECH	Now we don't know what this little…let's picture that..	M statement		
	28		NATE	POSTURE	***Nate leans back into desk***			
	29	3	MELLONY	SPEECH	there's numbers behind these things, okay?	M statement	General interaction	
	30		NATE	POSTURE	***Nate rests his chin on his hands and leans forward***			Explaining (2a)
34:19	31		MELLONY	SPEECH	So behind the clover is the same number for all the clovers.	M statement		
	32		MELLONY	GESTURE / GAZE	***Mellony gestures and points to the numerous clover shapes on the page, still looking at Zac***	M gesture		

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	33		NATE	POSTURE / GAZE	***Resting his chin in his hands, looking at the chart***			
	34		MELLONY	SPEECH	Okay? All the clovers are the same number, all the triangles are the same number, and all the circles are the same number.	M statement		
	35		MELLONY	GAZE	***Mellony continues to look at Zac, whose eyes are downcast***			
	36		NATE	POSTURE	***Playing with his face, resting thumbs on his forehead***			
	37		MELLONY	GAZE	***Glances at Nate***			
	38		ZAC	GAZE	***Still silent, but looking at the chart, eyes are downcast***			
	39		MELLONY	SPEECH	Does that make sense?	M question		Clarifying (2b)
	40		MELLONY	SPEECH	All of these, if we add up, and turn them over and we add up those numbers, they add up to 25, okay?	M statement		
34:35	41		MELLONY	SPEECH	If we turn these circles over they all together add up to 20.	M statement		
	42		MELLONY	GAZE	***Looks directly at Zac, whose eyes are downcast***			
	43		MELLONY	SPEECH	Every circle is the same, hey. And if we add up this column	M statement		
	44	4	MELLONY	GESTURE	***Mellony indicates the shapes in the 4th column on chart***			
	45		NATE	POSTURE	***Sits back in chair again***			
	46		*MELLONY*	SPEECH	then these add up to 26. You need to figure out what's the number behind the triangles	M statement		
	47		MELLONY	GAZE	***Mellony looks at Zac***			Explaining (2a)
	48		MELLONY	SPEECH	What's the number behind the triangle and what's the number behind the clover?	M question		
	49		MELLONY	GESTURE / GAZE	***Indicates each shape in the grid key.*** ***Mellony looks at Nate***	Eye contact M->L		
	50		NATE	GAZE	***Makes eye contact with Mellony***	Eye contact L->M		
	51		ZAC	GAZE	***Glances briefly at Nate***	Eye contact L->L		
	52		MELLONY	SPEECH	and what's the number behind the circle. All the circles have got the same number.	M statement		
34:59	53		ZAC	POSTURE	***Changes position in chair, places his paper and rests elbow on table***			
35:00	54	5	MELLONY	SPEECH	And you're welcome to discuss, you can do this one together alright?	M question		Inviting collaboration (1)
	55		MELLONY	GESTURE	***Makes an inclusive gesture to the 2 boys***			
35:06	56		NATE	SPEECH	This is going to be hard	L expressing something		
	57		MELLONY	EXPRESSION	***Mellony giggles***		M attention caught by learner expressing something (56)	
	58	6	NATE & ZAC	POSTURE	***Both boys lean in to the table***			
	59		NATE & ZAC	GESTURE / ACTION	***Zac and Nate point their pencils to the 2nd row on the chart and begin to work on the task, in whispers***			
35:11	60		NATE	GAZE	***Looks at Zac***			
35:13	61		DEBBIE	SPEECH	Can you speak loudly please, so we can hear, don't whisper			

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35:19	62		ZAC	SPEECH	***[Speaking slowly]*** So this will be 10 and 10 that will be 20. This will be 3 and 2	L expressing something		
	63		NATE	GAZE	***Nate looks at Zac***	Eye contact L->L		
	64		ZAC	GAZE / GESTURE	***Zac looks at Nate*** ***points to the 3rd row of the chart (the circles) and explains***	Eye contact L->L	L attention caught by learner expressing something and by caught by L->L eye contact (62-65)	
	65	7	ZAC	SPEECH	This will work out … 5, 10, 15, 20	L expressing something		
	66		ZAC	GESTURE / GAZE	***Zac counts backwards along the row of circles, still making eye contact with Nate***			
	67		NATE	SPEECH	Oooh ***(tone of realisation)***	L expressing something in direct response to other learner expressing something (65)	L attention caught by learner expressing something (65)	
	68		NATE	EXPRESSION / GESTURE	***Nate laughs and covers his head with his hand***			
35:28	69		ZAC	EXPRESSION / GAZE	***Short laugh and glance at Nate***			
	70		MELLONY	SPEECH	Okay, so why are you saying 5, 10, 15, 20?	M question	M attention caught by learner expressing something and by interaction (62-69)	Probing (2b)
35:36	71	8	ZAC	SPEECH	***[inaudible]*** Because…			
	72		ZAC	GAZE	***Zac looks at Mellony***	Eye contact L->M		
	73		ZAC	SPEECH	this is gonna have to be 5	L expressing something in direct response to m question (70)		
35:43	74	9	MELLONY	SPEECH	Okay, cool, so you've already figured out that the circle equals?	M question	M attention caught by learner expressing something and by L->M eye contact (72-73)	Valuing (1) Evaluating (1) Making actions explicit (2b)
	75		MELLONY	ACTION	***Mellony picks up her pencil, draws a circle on scrap paper and Zac writes a number***	M action		Using symbols (3)

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	76		NATE	GAZE	***Nate continues to look at the chart***			
35:47	77		ZAC	SPEECH	5	L expressing something in direct response to m question and action (74-75)	L attention caught by m action (75)	
	78			ACTION	***Writes "5" next to the circle***			
34:45	79		NATE	GAZE / GESTURE	***Continues looking at the chart and pointing to shapes***			
35:50	80		MELLONY	SPEECH	All right, no problem. Good.	M statement		Valuing (1) Evaluating (1) Encouraging (1)
	81		ZAC	ACTION / GESTURE	***Zac continues to calculate***			
	82		NATE	ACTION / GESTURE	***Nate looks on and then joins in again***			
	83		NATE & ZAC	ACTION / GESTURE	***Both boys point pencils to the 1st column on the chart***			
35:58	84		NATE	GAZE / ACTION	***Nate says something to Zac and looks at him***	L expressing something		
	85	10	ZAC	GAZE / ACTION	***Zac now looking at 1st row in grid***			
36:06	86		NATE	GESTURE / GAZE	***Nate points to the 2nd row on the grid and appears to be thinking. He then looks at Zac***	L gesture Eye contact L->L		
	87		ZAC	GAZE	***Turns his attention to the 2nd row by pointing his pencil***		L attention caught by l gesture and by L->L eye contact (86)	
36:10	88		NATE & ZAC	GAZE	***Boys make direct eye contact and say something to each other***	Eye contact L->L		
	89		ZAC	SPEECH	These will be 9	L expressing something		
	90		NATE & ZAC	GESTURE	***both boys point to the clubs***			None as boys are interacting
	91		NATE	UNCLEAR	***Nate says something inaudible, possibly "8"***		L attention caught by learner expressing something (89)	
	92		ZAC	SPEECH	9 ***[with emphasis]***	L statement		
	93	11	ZAC	GAZE	***looks at Nate***	Eye contact L->L		
	94		NATE	EXPRESSION	***Laughs***			
36:11	95		NATE	SPEECH	Oh		L attention caught by l statement and by L->L eye contact (92-93)	
	96		NATE	GESTURE	***Touches his forehead with his fingers***			
	97		ZAC	GESTURE /	***Pointing to the clubs in the 2nd row and grinning***			

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				EXPRESSION				
	98		ZAC	SPEECH	16	L statement		
	99		NATE & ZAC	ACTION	***They calculate the 2 clubs and the circle mentally***	L action		
	100		NATE	SPEECH	So this will be 2?	L expressing something		
	101		NATE	GAZE	***Nate looks at Zac***	Eye contact L->L		
	102	12	ZAC	SPEECH	Yes, and that will be 25	L expressing something in direct response to m question and action (100-101)	L attention caught by learner expressing something and by L->L eye contact (100-101)	
	103		ZAC	GAZE	***Zac looks at Nate briefly, both boys make eye contact***	Eye contact L->L		
36:19	104		MELLONY	SPEECH	Okay, so try. So you are telling me that these funny clovers, okay, these funny clovers are … ?	M question	M attention caught by learner expressing something (81-103)	Encouraging (1) Probing (2b) Using symbols (3)
	105		MELLONY	ACTION	***Mellony draws a club on scrap paper***	M action		
	106	13	ZAC	SPEECH	Are 9	L statement	L attention caught by m question and by m action (104-105)	
	107		MELLONY	SPEECH	… These funny clovers are 9. Put 9	M statement		Directing (2a) Using symbols (3)
	108		ZAC	ACTION	***Zac writes "9" next to the club shape***			
	109		MELLONY	SPEECH	and you are telling me that the triangle is 2	M statement		Making talk explicit (2b)
	110		MELLONY	ACTION	***Mellony draws a triangle on scrap paper***	M action		Using symbols (3)
	111		ZAC	ACTION	***Zac writes a "2" next to the triangle***	L action		
	112		NATE	GAZE	***Watches what is being written on Zac's paper***			
36:35	113	14	MELLONY	SPEECH	Okay? Fine. So now I'm checking	M statement		Modelling (2b)
	114		MELLONY	GESTURE	***Mellony points to shapes in 2nd row***			
	115	15	MELLONY	SPEECH	okay? 9 and 9 is 18 and 5 is 23, and 2 is 25. I'm very happy, ja. Now I want to check the column	M statement		Valuing (1) Modelling (2b)
	116		MELLONY	GESTURE	***Mellony indicates the 4th column***			
	117		MELLONY	SPEECH	This one says 26. Does it still work?	M question		Seeking justification (2b)
	118		ZAC	GESTURE	***Indicates 4th column with pencil***			
	119	16	ZAC	SPEECH	5, 10	L statement	L attention caught	

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	120		ZAC	GESTURE	***Zac points to the circles***		by m statement and by m question (115 & 117)	
	121		NATE	SPEECH	2, 4	L statement		
	122		NATE	GESTURE	***Nate points to the triangles***			
	123		ZAC	SPEECH	14	L statement		
	124		MELLONY	SPEECH	Oh, oh	M statement	M attention caught by l statements (119, 121 & 123)	
36:54	125		NATE	SPEECH	Eeew	Exclamation		
	126		NATE	GAZE	***Nate looks at Zac***	Eye contact L->L		
	127	17	ZAC	GESTURE / EXPRESSION	***Puts pencil to mouth and laughs***			
	128		NATE	SPEECH	it's wrong	L expressing something in direct response to m statement (124)		
36:57	129		NATE & ZAC	POSTURE / GAZE	***Both boys are hunched over the table, looking intently at the chart***			
	130		MELLONY	SPEECH	Okay? so we are going to revise. Am I right?	M question	M attention caught by learner expressing something (128)	Modelling (2b)
	131	18	MELLONY	ACTION	***Mellony scratches out the numbers against shapes on the paper***	M action		Using symbols (3)
	132		MELLONY	SPEECH	That was a good try but now we're going to revise. It worked one way, but it didn't work the other. It must work both ways.	M statement		Promoting joint understanding (2c) Explaining (2a)
	133		NATE & ZAC	SPEECH	***Boys discuss***		L attention caught by m action and by m statement (130-132)	
	134		NATE	GEATURE / GAZE	***repeatedly points to the 4th column whilst looking at Zac***	Eye contact L->L		
37:11	135	19	MELLONY	SPEECH	Think Nate, good.	M statement		Encouraging (1)
	136			GESTURE	***Touches Nate lightly on the arm***			
37:12	137		NATE	SPEECH	It's the circles and triangles …	Learner expressing something		
	138		NATE	GAZE / POSTURE	***Nate looks at Zac***			
	139		ZAC	GAZE / POSTURE	***Zac appears to be thinking, not looking at Nate. Makes a tiny movement in his chair***			
37:18	140	20	MELLONY	SPEECH	Explain	M statement		Asking for verbalisation of thinking / observations (2b)

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37:20	141		NATE	EXPRESSION	***Nate breathes out heavily***	L breath emphasis		
	142		MELLONY	SPEECH	You were working here on this column	M statement	M attention caught by l breath emphasis (141)	Making actions explicit (2b)
	143		MELLONY	GESTURE	***Mellony indicates 4th column***			
	144		NATE & ZAC	GAZE / EXPRESSION	***Both boys are looking at the chart, exclaiming***			
37:24	145		MELLONY	SPEECH	Tell us what you were doing Nate.	M statement		Asking for verbalisation of thinking / observations (2b)
	146	21	NATE	POSTURE / GAZE	***Nate leans back, makes brief eye contact with Mellony***	Eye contact L->M	L attention caught by L->M eye contact and by m statement (145-146)	
	147		MELLONY	SPEECH	Good. I liked your thinking	M statement		Encouraging (1) Valuing (1)
	148		NATE	POSTURE	***Nate leans back into paper again, with pencil on forehead***	Body movement		
	149		ZAC	GAZE	***Looking at the writing on his paper***			
37:31	150		NATE	POSTURE / GAZE	***Nate leans back again, glances at Mellony***	Eye contact L->M		
37:33	151		NATE	SPEECH	I was saying that the triangle and circle was wrong so they would have to be a different number.	Learner expressing something in direct response to M statement (147)		
	152		ZAC	GAZE	***Zac looks at Nate***	Eye contact L->L		
	153	22	ZAC	SPEECH	No the circle was wrong, no right	Learner expressing something	L attention caught by learner expressing something and by L->L eye contact (151-152)	
	154		NATE	SPEECH	Ja, the circle was right	Learner expressing something		
37:41	155		MELLONY	SPEECH	But the triangle was wrong?	M question	M attention caught by learner expressing something (153-154)	Prompting (2b)
	156		ZAC	SPEECH	Yes	L statement	L attention caught by m question (155)	
	157	23	MELLONY	SPEECH	Good, you are right. Okay			Encouraging (1)

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								Valuing (1)
	158		MELLONY	GESTURE	***Mellony points to Nate and touches his arm***	Touch Eye contact L->M		
	159		ZAC	GESTURE / GAZE	***Zac looks at Mellony***			
	160		NATE	GESTURE / GAZE	***Makes brief eye contact with Mellony***			
	161		MELLONY	SPEECH	So now try something else for the triangle. You know your triangle is wrong coz it doesn't work this way.	M statement		Making talk explicit (2b) Making actions explicit (2b)
	162		MELLONY	GESTURE	***Indicating the triangles in the 4th column***			
37:49	163		ZAC	SPEECH	And the clover	Learner expressing something in direct response to M statement (161)		
	164		ZAC	GAZE	***Looks at Mel***	Eye contact L->M		
	165		MELLONY	SPEECH	The clover is naturally then also going to be wrong. So, you are right, they are both not going to work.	M statement	M attention caught by L->M eye contact and by learner expressing something (163)	Making talk explicit (2b) Valuing (1)
	166		NATE & ZAC	ACTION	***Both boys point to and work on 2nd row***			
	167		ZAC	ACTION	***Zac continues working on 2nd row***			
38:01	168		NATE	ACTION	***Nate working on 4th column***			
	169	24	NATE & ZAC	GAZE / EXPRESSION	***They look at each other and giggle and say something inaudible, but possible "zero"***	L statement		
	170		NATE	POSTURE	***Wiggles in his chair whilst giggling***			
	171		MELLONY	SPEECH	If it's zero, 5 and 5 is ten and zero, you still don't get 26.	M statement	M attention caught by l statement (169)	Making actions explicit (2b)
38:08	172		NATE & ZAC	GAZE / EXPRESSION	***They look at each other and giggle again***			
	173		MELLONY	SPEECH	It's a good try.			Valuing (1)
	174	25	MELLONY	SPEECH	But I think you need to try and get the triangle a bit bigger, not smaller	M statement		Directing (2a) Promoting joint understanding (2c)
	175		MELLONY	GESTURE	***Mel indicates bigger with her hands and then the 4th column***	M gesture		
	176		MELLONY	SPEECH	am I right?	M question		
38:18	177		ZAC	GESTURE	***Zac still focussed on 2nd row, using pencil gestures***			
	178	26	NATE	GESTURE	***Nate still focussed on 4th column, using pencil gestures***			
38:22	179		NATE	GAZE / EXPRESSION	***Nate looks at Zac and he draws in his breath***	Eye contact L->L L breath emphasis		

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38:28	180		ZAC	GESTURE	***Zac transfers attention to 4th column by pointing pencil***		L attention caught by L->L eye contact and by l breath emphasis (179)	
	181		NATE	GESTURE	***Points to the total for 4th column***			
	182		ZAC	ACTION / GAZE	***Zac adds the circles and glances briefly at Nate***			
	183		ZAC	SPEECH	10 …	L expressing something		
	184		NATE	SPEECH	No its an 18		L attention caught by learner expressing something (183)	
	185		NATE	GAZE	***Looks at Zac***			
	186		ZAC	GAZE	***Looks at Nate and then back at the grid***			
38:36	187		MELLONY	SPEECH	Okay, if the triangle was 10, what would you get?	M question	M attention caught by learner expressing something (183-184)	Probing (2b)
	188	27	NATE	EXPRESSION / POSTURE / ACTION	***Nate breathes in, leans back and starts counting on his fingers***	L breath emphasis L action	L attention caught by m question (187)	
	189		MELLONY	SPEECH	If the triangle was 10 what would you get in that column?	M statement	M attention caught by l action, by l breath emphasis (188)	Encouraging (1)
	190		NATE	EXPRESSION / GAZE / GESTURE	***Nate grins, looking at Zac and pointing pencil at him***	Eye contact L->L		
	191		MELLONY	SPEECH	Okay, try it, try it, try it.	M statement		Encouraging (1)
38:41	192		NATE	SPEECH	Hey	Exclamation	L attention caught by m statement (189 & 191)	
	193			SPEECH	8	L statement		
	194	28	MELLONY	GESTURE	***Mel touches his shoulder with her finger***	M touch		Encouraging (1)
	195		NATE	INTONATION	***Then he says more loudly***	Learner expressing something in direct response to touch	L attention caught by m touch (194)	
	196		NATE	SPEECH	it's 8!			
	197		NATE	POSTURE	***Nate leans back***	Body movement		
38:44	198		MELLONY	SPEECH /	Ja. Ja ***[rising intonation]***	M statement	M attention caught	Encouraging (1)

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				INTONATION			by learner expressing something (196)	
	199		NATE	POSTURE	***Nate leans back in and looks at Zac***	Body movement		
	200		NATE & ZAC	SPEECH	***[in unison]*** 8 and 8 is 16	Learner expressing something	L attention caught by m statement (198)	
	201		ZAC	SPEECH	16 plus 10, is 26	Learner expressing something		
	202		NATE	GAZE & EXPRESSION	***Nate looks at Zac and smiles***	Eye contact L->L		
	203		ZAC	GESTURE	***Plays with the neck of his jacket***			
38:52	204		MELLONY	SPEECH	Woo hoo	Exclamation	M attention caught by learner expressing something (200-201)	Encouraging (1)
	205		DEBBIE	SPEECH	How did you get that Nate?	M question		Making thinking explicit (2b)
	206		NATE	EXPRESSION & GAZE	***Nate smiles and looks directly at the camera***	Eye contact L->M	L attention caught by m question (205)	
	207		ZAC	GAZE / POSTURE	***Looks at Nate, shifts in his chair and leans on the table***			
39:00	208		NATE	SPEECH	Well, I was counting, so what equals… so 10, 18 plus what equals 26? And I just counted on … in 8s …	L expressing something		
	209		NATE	GESTURE	***Points to the shapes in column 4 whilst explaining***			
	210	29	ZAC	ACTION	***Zac listens and checks the numbers himself***			
	211		NATE	GAZE	***Nate looks at Zac***	Eye contact L->L		
	212		MELLONY	SPEECH	Because 8 and 8 is …?	M question		Prompting (2b)
	213		MELLONY	GESTURE	***Mellony points to Nate***	M gesture		
	214		NATE	GAZE	***Looks at Mellony making eye contact***	Eye contact L->M		
	215		NATE	SPEECH	***[pauses whilst thinking]*** 16	L expressing something in direct response to question (212)	L attention caught by m question (212)	
	216	30	MELLONY	SPEECH	Well done. Okay. All right, so it was 16 plus the 10, is 26. Am I right?	M statement M question		Encouraging (1) Promoting joint understanding (2c)
	217		NATE	GAZE	***Looks briefly at Zac***			
	218		ZAC	GAZE	***Looking at the activity***			

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	219		MELLONY	SPEECH	All right, so it was 16 plus the 10, is 26. Am I right?	M statement M question		Encouraging (1) Promoting joint understanding (2c)
	220		NATE	SPEECH	Hmm ***[in agreement]***			
	221		NATE	EXPRESSION	***Slight nod of his head***			
	222		MELLONY	SPEECH	Okay, so well done. So now you are pretty convinced	M statement		Encouraging (1) Promoting joint understanding (2c)
	223		MELLONY	GESTURE	***Mellony points to paper with notes***			Using symbols (3)
	224		MELLONY	SPEECH	Revise this, you can do it one piece of paper. Well done Nate	M statement		Directing (2a) Encouraging (1)
	225		ZAC	ACTION	***Changes the values on the paper***	L action		
	226		MELLONY	GESTURE	***Mellony pats Nate on the shoulder***	Touch		
	227	31	MELLONY	SPEECH	He figured out this one is 8	M statement		Making talk / actions explicit (2b)
	228		MELLONY	GESTURE	***Pointing to the triangle on scrap paper***			
	229		MELLONY	SPEECH	Now as you said …	M statement		Making talk / actions explicit (2b)
	230		MELLONY	GESTURE	***Mellony indicates Zac***			
	231		ZAC	GAZE	***Very brief look at Mellony***			
	232		MELLONY	SPEECH	… the clover has also got to be wrong because if you've now changed the triangle, so let's see.	M statement		
39:40	233		NATE & ZAC	GAZE / EXPRESSION / POSTURE	***Boys look at each other and giggle***	Eye contact L->L Body movement	L attention caught by m statement (229 & 232)	
	234		NATE	POSTURE	***Nate leans back and in again***			
	235		ZAC	GESTURE	***Zac continues to work on 2nd row, gesturing with his pencil***			
39:47	236		NATE	POSTURE / GAZE	***Nate moves in and out, looking at Zac***			
	237		MELLONY	GESTURE	***Mel touches Nate on shoulder***	M touch		
	238	32	MELLONY	SPEECH	Have a look Nate	M statement		Directing (2a)
	239		NATE	POSTURE / GESTURE	***Nate leans back in and works with Zac on the 2nd row, using his pencil to point***		L attention caught by m touch and m statement (237-238)	
39:50	240		MELLONY	SPEECH	You were so good on the triangle. You figured it out my boy.	M statement		Encouraging (1) Making talk explicit (2b)
39:54	241		ZAC	SPEECH	13 Plus 10 …	Learner expressing something		
	242	33	NATE	GAZE	***Looks at Zac***			
	243		NATE	SPEECH	No	L statement		

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	244		ZAC	SPEECH	plus 8 ….21	Learner expressing something		
	245		ZAC	GAZE / ACTION	***Zac looks at Nate, calculating aloud***	Eye contact L->L		
40:09	246		ZAC	SPEECH	So this is 6, 6,	Learner expressing something		
	247		ZAC	SPEECH	Wait … 12, 17			
	248		NATE	GAZE	***Looks at Zac***			
	249		NATE & ZAC	POSTURE	***both boys move in their chairs***			
	250		NATE	POSTURE / GESTURE	***Leans out and then in, covering his face with his hand***			
	251		ZAC	SPEECH	6, 6, 12 plus 5, 17 ..plus 8	Learner expressing something		
	252		NATE	GAZE	***Looking at Zac whilst he calculates***			
	253		ZAC	SPEECH	…..it's 25	Learner expressing something		
	254		ZAC	POSTURE / GAZE	***Sits back, looks at Nate***			
	255		NATE	GAZE	***Nate looks at Mellony***	Eye contact L->M		
40:30	256		MELLONY	SPEECH	Cool. You figured it out then you can do a double check. Write it down. Write down what you think.	M statement	M attention caught by learner expressing something and by L->M eye contact (253 & 255)	Valuing (1) Making talk explicit (2b) Using symbols (3)
	257	34	NATE & ZAC	ACTION / EXPRESSION	***They both write, giggle and exclaim***			
	258		ZAC	SPEECH	a six	L statement		
	259		ZAC	ACTION / EXPRESSION	***Zac writes on the paper next to the club shape***	L action		
	260		MELLONY	EXPRESSION	***Laughs***			
40:39	261		MELLONY	SPEECH	Okay, double check. Convince me. Show me.	M statement		Seeking justification (2b) Promoting joint understanding (2c)
	262			GAZE	***Both boys look at the activity***			
	263	35	NATE & ZAC	SPEECH	If it's 6, plus another 6, 12, plus 5, it's 17, plus 8 is 25.	Learner expressing something		
	264		NATE	EXPRESSION / GAZE	***Grins and looks at Zac***	Eye contact L->L		
	265		ZAC	GAZE	***Looks up and makes eye contact with Mel***	Eye contact L->M		
	266	36	MELLONY	SPEECH	Cool. I'm convinced. Now convince me this way	M statement	M attention caught by learner	Seeking justification (2b) Promoting joint

Time segment starts and ends	Transcript line number	(* indicates start & end of	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
							expressing something (263)	understanding (2c)
	267		MELLONY	GESTURE	***Mellony indicates another column***			Directing (2a)
	268		NATE & ZAC	SPEECH	10, yoh, 5, 5, 10 plus 8 plus 8 … is 16, 26.	Learner expressing something		
41:06	269	37	ZAC	SPEECH	Ja, 26	Learner expressing something	L attention caught by learner expressing something (268)	
	270		MELLONY	SPEECH	Cool, so now do you think you could fill in these other ones? What do you think this top row will be? We'll just do one what do you think this top one will be?	M question		Directing (2a) Promoting joint understanding (2c)
	271	38	NATE & ZAC	ACTION / GESTURE	***Both boys refer to values written next to symbols and Nate points to each shape on the chart*** 	L action L gesture	L attention caught by m question (270)	
	272			SPEECH	8 plus 6, equals 14, plus another 8, plus another 8			
	273		NATE & ZAC	EXPRESSION	***both giggle***	Learner expressing something in direct response to question (270)		
	274			SPEECH	plus another 8, 14			
	275		NATE	ACTION	***Nate counts on fingers***			
	276		ZAC	SPEECH	22 plus 5 it's 26			
41:36	277	39	MELLONY	SPEECH	22 plus 5?	M question	M attention caught by learner expressing something (272-276)	Prompting (2b)
	278		NATE	SPEECH	26	Learner expressing something in direct response to question (277)		
	279		ZAC	SPEECH	27	Learner expressing something in direct response to question (277)		
	280		MELLONY	SPEECH	22 plus 5?	M question		Prompting (2b)
	281		NATE & ZAC	GAZE	***boys look at each other***	Eye contact L->L		

Time segment starts and ends	Transcript line number	(* indicates start & end of	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
	282	[redacted]	ZAC	EXPRESSION	***Zac grins at Nate***			
	283	[redacted]	ZAC	SPEECH	plus 5?	L question	L attention caught by m question and by L->L eye contact (280 & 283)	
41:44	284	[redacted]	NATE	SPEECH / EXCLAMATION	Aaah	Exclamation	L attention caught by l question (283)	
41:49	285	[redacted]	NATE	SPEECH	27	L statement		
	286	[redacted]	NATE	GESTURE	***Nate makes a hand gesture in confirmation***	L gesture		

End of Episode Two

Episode Three: Luhlaza Primary girls transcript

Time segment starts and ends	Transcript line number	Turn (* indicates start & end of critical event)	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
0:00	1	1	DEBBIE	ACTION	***Places the activity sheet on the desk between the girls***	Activity		
	2		DEBBIE	SPEECH	Alright, now let's just look at the shapes that we have got here.			Setting the scene (1)
	3		KUHLE & AKHONA	GAZE	***both girls look at activity then at the sun streaming through the window, with elbows on desk***			
	4	2	DEBBIE	SPEECH	What shape is this? Girls?	M question		Prompting (2b)
	5		DEBBIE	GESTURE	***Debbie points to triangle in 1st row***			
	6		KUHLE & AKHONA	SPEECH	***[pause]*** Triangle			
	7		DEBBIE	SPEECH	What about this one?	M question		Prompting (2b)
	8		DEBBIE	GESTURE	***Debbie points to club in 1st row***			
0:19	9		AKHONA	EXPRESSION / GAZE	***Grins and looks at Kuhle and then at Debbie***			
	10		DEBBIE	SPEECH	Where have you seen this one before?	M question		Probing (2b) Connecting (3)
	11		AKHONA	SPEECH	Cards	L statement		
	12		AKHONA	GAZE	***Looks directly at Debbie***			
	13		KUHLE	EXPRESSION	***Looks up, smiles, then looks at Debbie***			Prompting (2b)
	14		DEBBIE	SPEECH	Cards, aah. So what is it called again, can you remember?	M question		
	15		DEBBIE	GESTURE	***Gestures towards Akhona***			
	16		AKHONA	EXPRESSION / GAZE	***Frowns a little and looks into the distance***			
	17		KUHLE & AKHONA	GAZE / EXPRESSION	***both girls look at Debbie, grinning***			
	18		KUHLE	SPEECH	Spades?	L statement		
	19		DEBBIE	SPEECH	Close…			Funneling (2a)
	20		AKHONA	SPEECH	Aaah			
	21		KUHLE	SPEECH	Fly?			
0:33	22		DEBBIE	SPEECH	Clubs. Remember that? Strange word isn't it?			Explaining (2a)
	23		DEBBIE	GAZE	***Makes eye contact with Akhona***	Eye contact M->L		
	24		KUHLE	GAZE	***Distracted by something behind Debbie***			
	25		MELLONY	SPEECH	like a maths club.			

Time segment starts and ends	Transcript line number	Turn (* indicates start & end of critical event)	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
	26		DEBBIE	SPEECH	And what's this shape?	M question		Funneling (2a)
	27		KUHLE & AKHONA	GAZE	***Both girls look at the paper***		L attention caught by question (26)	
	28		KUHLE & AKHONA	SPEECH	Circle	L statement		
	29		KUHLE & AKHONA	GAZE	***Both girls continue to look at paper***			
	30		DEBBIE	SPEECH	Alright now if you look at this, what I want to know	M statement		
	31		KUHLE & AKHONA	EXPRESSION / POSTURE	***both girls frown slightly and lean back in their chairs***			
	32		DEBBIE	SPEECH	I want to know for each of these shapes, I want to know what number they represent.	M statement		Explaining (2a)
	33		DEBBIE	GESTURE	***Points to the 3rd row***			
	34		KUHLE & AKHONA	GAZE	***both girls look at Debbie***			
	35	3	DEBBIE	SPEECH	I want you to work out - each of these shapes has got a number. OK?	M statement		Explaining (2a)
	36		DEBBIE	GESTURE	***Uses a hand gesture as emphasis***			
	37		DEBBIE	SPEECH	You haven't got a lot of information here, you've got to work out with the information you've got.	M statement		
	38		DEBBIE	GESTURE	***Uses a hand gesture as emphasis***			
	39		DEBBIE	SPEECH	You've got some information here	M statement		Directing (2a)
	40		DEBBIE	GESTURE	***Debbie points to a total on the grid***	M gesture		
	41		DEBBIE	SPEECH	You've go to work out what you think each of these shapes' numbers could be.	M statement		
	42		DEBBIE	GESTURE	***Points to the 3rd row***	M gesture		
	43	4*	AKHONA	GAZE	***Staring intently at the grid***			
	44		KUHLE	POSTURE	***Bobbing backward and forward in her chair***			

Time segment starts and ends	Transcript line number	Turn (* indicates start & end of critical event)	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
	45		AKHONA	SPEECH	Yes		L attention caught by gesture, attention caught by statement (41-42)	
1:14	46		AKHONA	POSTURE / EXPRESSION / ACTION	***Akhona grins, sits up and puts her thumb to her chest***	L action	L action modified by attention caught	
	47		KUHLE	GAZE	***Sits staring into the distance***			
	48		DEBBIE	SPEECH	So you are going to work it out together.	M statement		Inviting collaboration (1)
	49		AKHONA	EXPRESSION / GESTURE	***Akhona smiles and points to the circle***			
	50		KUHLE	GAZE	***Kuhle looks on***			
	51		AKHONA	SPEECH	5	L expressing something L gesture	L action modified by attention caught (41)	
	52		AKHONA	GESTURE	***Points to the first circle in 3rd row and grins***			
	53	5	DEBBIE	SPEECH / INTONATION	Ooh, ***[rising intonation]*** OK. GO GO!	Exclamation	M attention caught by learner expressing something (51/2)	Encouraging (1)
	54		AKHONA	SPEECH	That is 5 plus 5. 10 plus 5	L expressing something		
	55		KUHLE	SPEECH	15	L statement		
	56		AKHONA	SPEECH	Plus 5 is 20.	L expressing something		
	57		AKHONA	GAZE	***Kuhle sits back, with arms crossed***			
1:26	58		AKHONA	GAZE	***Akhona looks at her***			

Time segment starts and ends	Transcript line number	Turn (* indicates start & end of critical event)	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
	59		DEBBIE	SPEECH	So this here is the total?	M question	M attention caught by learner expressing something (54-56)	Probing (2b)
	60	6*	DEBBIE	GESTURE	***Debbie points to the row of circles***	M gesture		
	61		DEBBIE	SPEECH	It's the sum? So you are saying the circles are?	M question		Clarifying (2b)
	62		AKHONA	SPEECH	5	L expressing something		
	63		AKHONA	GAZE	***Akhona looks directly at Debbie***	Eye contact L->M		
1:36	64		DEBBIE	SPEECH	So put a 5 here next to the circle.	M statement		Directing (2a) Using symbols (3)
	65		DEBBIE	GESTURE	***Debbie points to the key at the bottom of the page***	M gesture		
	66	7	AKHONA	ACTION	***Akhona starts to write, then takes her hand away***	L action	L attention caught by statement, gesture (65-65)	
	67		KUHLE	ACTION	***Kuhle writes a 5 next to the circle***			
	68		AKHONA	GAZE	***Akhona watches her***			
	69		DEBBIE	SPEECH	Now I want to….			
	70		DEBBIE	SPEECH	Do you agree with that, Kuhle, sorry?	M question		Seeking agreement (2b)
	71		DEBBIE	GESTURE	***Debbie touches Kuhle on the back***	Touch		
	72		KUHLE	GAZE	***Kuhle nods imperceptibly and looks at Debbie***	Eye contact L->M		
	73	8	DEBBIE	SPEECH	Now I want you to work out what this club is, what this triangle is, with the other information that you've got.	M statement		Directing (2a)
	74		KUHLE & AKHONA	GAZE	***both girls look at the paper***			
	75		DEBBIE	SPEECH	OK, so work together if you want or you… yeah?	M statement		Inviting collaboration (1)
	76		DEBBIE	GESTURE	***Makes an inclusive gesture***			
	77		KUHLE	GAZE	***Glances sideways at Debbie***			
	78		AKHONA	GESTURE	***Akhona points to the club at the top of the 4th column***			
	79	9	KUHLE	GESTURE	***Kuhle moves the paper towards her***	L gesture		
1:48	80		DEBBIE	SPEECH	That is a really good start, getting that	M statement		Encouraging (1) Valuing (1)

Time segment starts and ends	Transcript line number	Turn (* indicates start & end of critical event)	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
	81		DEBBIE	GESTURE	***Debbie turns the paper centrally and points to the row of circles***	M gesture		
	82		DEBBIE	SPEECH	Now you can see what is next	M statement		Directing (2a)
	83		KUHLE & AKHONA	POSTURE	***Both girls move closer together and start talking softly***		L attention caught by m statement / attention caught by m gesture (80-82)	
2:04	84		AKHONA	GAZE	***Akhona looks at Kuhle***	Eye contact L->L		
	85		DEBBIE	GESTURE	***Kuhle points to the row of circles***			
	86		DEBBIE	GESTURE	***Debbie touches Kuhle on the back***	Touch		
	87		DEBBIE	SPEECH	Talk louder if you can, if you can			
	88		KUHLE & AKHONA	GAZE	***Girls briefly make eye contact with each other***	Eye contact L->L		
	89		KUHLE	SPEECH	5 ***[drawn out and a little louder]***			
	90	10	KUHLE	GESTURE	***Kuhle points to the circle at the top of the 4th column***			
	91		AKHONA	POSTURE	***Akhona rests her chin on her hand***			
2:14	92		DEBBIE	SPEECH	you can write on here if you want to so if you wanna put things next to those, it is up to you.			Directing (2a)
	93		DEBBIE	GESTURE	***Debbie indicates the shapes on the activity sheet***			
2:34			MELLONY		***mentions that they might want to use kokis.***			
2:36	94		KUHLE & AKHONA	POSTURE	***Girls have heads together and continue to work***			
	95	11	KUHLE	GESTURE / ACTION	***Gestures to the top 2 rows with her pencil and counting something on her fingers***	L action		
	96		KUHLE	POSTURE / ACTION	***Sits up in her chair and continues to work out something with her fingers***			
2:45					***Interlude whilst Debbie and Mellony are offered coffee by school staff, during this time, the girls are a little distracted but keep looking at the activity***			
3:25	97	12	DEBBIE	SPEECH	So tell us what you are thinking? What, how are you going to do the next bit?	M question		Asking for verbalisation of thinking (2b)

Time segment starts and ends	Transcript line number	Turn (* indicates start & end of critical event)	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
	98		AKHONA	SPEECH	I don't know ***[almost inaudible]***	L expressing something (in direct response to M question (97)		
	99		KUHLE	SPEECH	we don't know these numbers			
	100		KUHLE	GESTURE	***Kuhle points to the other shapes***			
	101		DEBBIE	SPEECH	No you don't!	M statement		Directing (2a)
	102		AKHONA	SPEECH	Yes	L statement		
	103		AKHONA	POSTURE / GAZE	***Sits back in her chair and looks at Debbie***			
3:33	104		KUHLE	GAZE	***Looks at Debbie***			
	105	13	DEBBIE	SPEECH	But what do you know, what else have you got, what other information do you have?	M question		Directing (2a) Probing (2b)
	106		KUHLE	SPEECH	the circles ***[quietly]***	L statement		
	107		DEBBIE	SPEECH	Sorry?			
	108		KUHLE & AKHONA	SPEECH	The circles	L statement		
	109		AKHONA	POSTURE / GAZE / EXPRESSION	***Leaning across the table, looks intently at Debbie, frowning slightly***			
	110		KUHLE	GAZE	***Looks sideways at Debbie, pencil to her mouth***			
	111	14	DEBBIE	SPEECH	You have got circles. OK, so can I give you a little bit of an idea, I am not gonna tell you how to do it.	M statement		Directing (2a)
	112		KUHLE & AKHONA	GAZE	***Both girls look at Debbie***			
	113		AKHONA	POSTURE	***Sits back in her chair and puts her hand on her head***			
	114		DEBBIE	SPEECH	You know that this is equal to?	M question		Funneling (2a)
	115		DEBBIE	GESTURE	***Debbie points to the total for the row of circles***			
	116		KUHLE & AKHONA	SPEECH	20	L statement		
	117		DEBBIE	SPEECH	20, and each circle is?	M question		Funneling (2a)
	118		KUHLE & AKHONA	SPEECH	5 ***[in unison]***	L statement		
	119	15	DEBBIE	SPEECH	Five. Okay so here's another place where it has given us an answer.	M statement		Directing (2a)
	120		DEBBIE	GESTURE	***Debbie points to the total for the 4th column***			

Time segment starts and ends	Transcript line number	Turn (* indicates start & end of critical event)	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
3:57	121		KUHLE & AKHONA	GAZE	***Both girls continue to look at the chart whilst Debbie talks***			
	122		DEBBIE	SPEECH	Okay, so we have got one circle and another circle, how much does that equal?	M question		Funneling (2a)
	123		AKHONA	POSTURE / GAZE	***Leans on the table, looking at what Debbie is indicating***			
	124		KUHLE & AKHONA	GAZE	***Both girls look at Debbie***			
	125		KUHLE & AKHONA	SPEECH	10	L statement		
	126		DEBBIE	SPEECH	okay and what does the whole column equal?	M question		Funneling (2a)
	127		DEBBIE	GESTURE	***Debbie points to the total for the 4th column***			
	128		KUHLE & AKHONA	SPEECH	Ummm, 26 ***[very softly]***	L statement		
	129		DEBBIE	SPEECH	26. How could we work out what those 2 are?	M question		Probing (2b)
	130		DEBBIE	GESTURE	***Debbie points to the two triangles in the 4th column***			
	131		DEBBIE	SPEECH	If this is 5, and this is 5? See if you can work out what those triangles are	M statement		Prompting (2b) Modelling (2b)
4:17	132		DEBBIE	ACTION	***Debbie writes '5' against each circle in column 4***			
	133		KUHLE & AKHONA	GAZE	***Both girls still looking at the chart and what Debbie is indicating***			
	134		AKHONA	GESTURE	***Akhona gestures with her pencil and turns the paper towards her***			
	135		KUHLE	EXPRESSION / GESTURE	***Kuhle sighs and points to the 4th column***			
	136		AKHONA	SPEECH	hmm, it's …	L statement		
	137	16	AKHONA & KUHLE	GAZE	***girls look at each other***			
4:31	138		KUHLE	GESTURE / GAZE	***Kuhle points to the 26 at the bottom of the 4th column and counts on her fingers, glancing sideways at Debbie as she does***			
	139		AKHONA & KUHLE	POSTURE / ACTION	***Akhona pulls back her sleeves and starts counting on her fingers***	L action		
	140		KUHLE	SPEECH	10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20			
	141			GAZE / ACTION	***Kuhle looks at the ceiling, calculating, then at Debbie***			

Time segment starts and ends	Transcript line number	Turn (* indicates start & end of critical event)	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
4:45	142		KUHLE	SPEECH	13 ***[softly]***	L expressing something		
	143		KUHLE	GAZE / EXPRESSION	***Looking at Debbie, small grin on her face***			
	144		AKHONA	GAZE / ACTION	***Glances at Kuhle briefly, then at Debbie, continues to count on her fingers***			
	145	17	DEBBIE	SPEECH	Hmm? Thirteen? Let's see what Akhona gets ***[talking to Kuhle]***	M statement		Clarifying (2b)
	146		DEBBIE	SPEECH	***[To Kuhle]*** So you are saying that the 2 triangles equal 13?	M question		Clarifying (2b)
	147		DEBBIE	GESTURE	***Debbie points to the two triangles***			
	148		KUHLE	SPEECH	13	Learner expressing something in direct response to M question (146)	L attention caught by m question (146)	
	149		DEBBIE	SPEECH	So here, put 13 for Kuhle. She says "13"	M statement		Directing (2a) Using symbols (3)
	150		DEBBIE	ACTION	***Debbie writes 13 next to the triangle on the key***			
	151	18	DEBBIE	SPEECH	***[To Akhona]*** You carry on and tell me what you think the 2 triangles are.	M statement		
	152	19*	AKHONA	GAZE / POSTURE	***Akhona frowns, stares at Debbie, chin in her hand***		L attention caught by m statement (151)	
	153		KUHLE	POSTURE / ACTION	***Kuhle sits back and continues to silently count on fingers***	L action		
	154		AKHONA	ACTION	***Akhona also starts to count on her fingers again***	L action		
5:08	155		AKHONA	GESTURE / ACTION	***Akhona picks up her pencil and starts to write on blank paper***			
	156		KUHLE	GAZE	***Kuhle has stopped counting and is looking (indirectly) at Akhona's working, glancing at Debbie and around the room***		Attention NOT caught	
	157		KUHLE	GESTURE	***Kuhle plays with her mouth***			
	158		AKHONA	ACTION	***Akhona continues to work***			

Time segment starts and ends	Transcript line number	Turn (* indicates start & end of critical event)	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
5:22	159	20	DEBBIE	SPEECH	So what is your answer Akhona?	M question		Asking for verbalisation of thinking (2b)
	160		AKHONA	GAZE / ACTION	***Akhona looks up from her work and then continues, talking to herself***	L action		
5:27	161		AKHONA	ACTION	***Both girls are silent, Akhona continues to work*** ***She has written "26-10=16" at the bottom of her paper*** ***Above this she writes "16-"***			
5:34	162		AKHONA	ACTION	***Akhona draws a box on her paper and writes "16" in it, all the time whispering to herself***			
5:38	163		AKHONA	ACTION	***Akhona draws more draws boxes on her paper, putting numbers in each box***			
5:40	164		KUHLE	POSTURE / EXPRESSION	***Kuhle sits back in her chair, smiling but not doing anything***		Attention NOT caught	
5:43	165		KUHLE	POSTURE / GAZE	***Kuhle puts her chin on the desk and sneaks a look at what Akhona is doing***			
5:44	166		DEBBIE	SPEECH	Okay	M statement		
	167		AKHONA	ACTION	***Akhona continues, uninterrupted***			
	168		MELLONY	SPEECH	***[whispers***] let's let her finish	M statement		
	169		DEBBIE	GESTURE	***Debbie picks up a pencil***	M gesture		
	170		KUHLE	EXPRESSION / POSTURE / GAZE	***Kuhle smiles, sits back in her chair, then grabs a pencil, stands up and looks at Debbie, then around room***			
	171		AKHONA	ACTION	***Akhona continues to work on her paper***	L action		
5:54	172	21	DEBBIE	SPEECH	Explain what you are doing there, Akhona	M statement	M attention caught by l action (171)	Asking for verbalisation of thinking (2b)
	173		AKHONA	POSTURE / GESTURE	***Akhona sits back and puts down her pencil***	L gesture		
5:55	174		AKHONA		***Akhona's workings show her final box is empty*** ***She pauses before answering***			

Time segment starts and ends	Transcript line number	Turn (* indicates start & end of critical event)	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
	175		AKHONA	SPEECH / EXPRESSION	I want a half ***[drawn out]***	L expressing something (in direct response to M statement (172)		
5:58	176		DEBBIE	SPEECH / INTONATION	You want a half? ***[rising intonation]***		M attention caught by learner expressing something (175)	Making talk explicit (2b)
	177	22	DEBBIE	SPEECH	Okay. So what did you get?	M question	** Break in flow	
	178		AKHONA	GAZE / POSTURE	***Akhona looks at her workings and rests chin in her hand***			
	179		DEBBIE	SPEECH	You said 26 minus 10 was 16	M statement		Making actions explicit (2b)
6:10	180		AKHONA	SPEECH	yes	L statement		
	181		DEBBIE	SPEECH	and now you are trying to work out what half of this is. Is that what you are trying to do?	M statement M question		Clarifying (2b)
	182		AKHONA	SPEECH	Yes	L statement		
	183		DEBBIE	SPEECH	Okay. So tell me what.. tell me how you've done that then	M statement		Asking for verbalisation of thinking (2b)
6:15	184		AKHONA	SPEECH	***begins to talk but unclear what she says***			
	185		AKHONA	GESTURE / ACTION	***Akhona points to the boxes on her workings and writes "8" in the final one***	L action		
	186	23*	DEBBIE	SPEECH	What do you think half is? You've got your answer!	M statement	M attention caught by l action (185)	Prompting (2b) Valuing (1)
	187		AKHONA	GESTURE	***Akhona points to the box at the bottom of her workings which contains an 8***	L gesture		
	188		AKHONA	SPEECH	8	L expressing something (in direct response to M statement (186)		

Time segment starts and ends	Transcript line number	Turn (* indicates start & end of critical event)	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
	189		DEBBIE	SPEECH / INTONATION	Wow, it's 8	M statement	M attention caught by learner expressing something (188)	Encouraging (1)
6:23	190		AKHONA	POSTURE / GAZE / EXPRESSION	***Akhona sits up straight and looks directly at Debbie, smiling***	Eye contact L->M	L attention caught by m statement (189)	
	191		KUHLE	EXPRESSION / GAZE	***Kuhle opens her mouth wide and looks at Debbie***			
6:25	192		DEBBIE	SPEECH	So what are you saying, Akhona?	M question	M attention caught by L->M eye contact (190)	Asking for verbalisation of thinking (2b)
	193		AKHONA	POSTURE / GAZE	***crosses arms on desk, looks directly at Debbie***	Eye contact L->M		
	194		AKHONA	GESTURE	***points to the activity page***	L gesture		
	195	24	AKHONA	SPEECH	Its 8	L expressing something (in direct response to M question (192)	L talk modified by attention caught	
	196		KUHLE	GESTURE / EXPRESSION	***points vaguely at the activity paper with her pencil and grins***			
	197		DEBBIE	SPEECH	Okay	M statement		
6:33	198		DEBBIE	SPEECH	***[To Kuhle]*** Do you see what she is doing?	M question		Funneling (2a)
	199		KUHLE	SPEECH	Yes	L statement		
	200	25	KUHLE	EXPRESSION / GESTURE / GAZE	***Kuhle nods, pencil in front of her mouth, vaguely looking at the activity sheet***			
6:34	201		DEBBIE	GESTURE	***Debbie points to Akhona's workings***			
	202		AKHONA	EXPRESSION / GAZE	***Akhona frowns, looks at her workings***			
	203		DEBBIE	SPEECH	I think what Akhona's done; I am just trying to say what she's done…			
	204	26	DEBBIE	SPEECH	26 minus 10..	M statements		Making actions explicit (2b)
	205		DEBBIE	GESTURE	***Debbie points to 26 on the activity sheet***			
	206		DEBBIE	SPEECH	so we have got 26 and we knew this was 10			

Time segment starts and ends	Transcript line number	Turn (* indicates start & end of critical event)	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
	207		KUHLE	POSTURE / GAZE	***Sitting back, pencil on her cheek, eyes downcast***			
	208		AKHONA	POSTURE / GAZE	***Leaning forward, looking intently at what Debbie is indicating***			
	209		DEBBIE	GESTURE	***Debbie points to activity sheet***			
	210		KUHLE & AKHONA	SPEECH	Yes ***[quietly]***	L statement		
	211		DEBBIE	SPEECH / EXPRESSION	so these 2 together ***[with emphasis]*** were…?	M question		Making actions explicit (2b)
	212		KUHLE & AKHONA	SPEECH	16	L statement		
6:46	213	27	DEBBIE	SPEECH	And then you said if it is 16 together, then I have to find half of that. Yes?	M question		Making actions explicit (2b)
6:54	214		AKHONA	GAZE / POSTURE	***looks at Debbie, then at her workings and sits back in her chair***			
	215		DEBBIE	SPEECH	So you got 8.	M statement		Clarifying (2b)
	216		AKHONA	GAZE / POSTURE	***Akhona sits forward again and glances at Debbie***			
6:58	217		DEBBIE	SPEECH	***[to Kuhle]*** Do you agree with that?	M question		Seeking agreement (2b)
	218	28	AKHONA	GAZE	***Akhona looks at Kuhle***	Eye contact L->L		
	219		KUHLE	SPEECH	yes ***[drawn out]***	L statement		
	220		KUHLE	POSTURE	***Still sitting back, playing with her pencil***			
6:59	221		DEBBIE	SPEECH	So put the 8 next to that then	M statement		Directly (2a) Using symbols (3)
	222		DEBBIE	GESTURE	***Debbie indicates the key on the activity sheet***			
	223	29	KUHLE	ACTION / GESTURE	***Kuhle writes the 8 on the sheet, moving the paper in front of her***	L action	L attention caught by m statement (221)	
	224		DEBBIE	SPEECH	and now see if you can work out the last one. What is the club going to be?	M question		Directing (2a)
	225		DEBBIE	GESTURE	***Debbie moves the paper back into the centre***			
7:09	226		DEBBIE	SPEECH	Because now you have quite a lot of information.	M statement		Directing (2a)
	227	30	AKHONA	SPEECH	Here?	L question	L attention caught by m statement (226)	
	228		AKHONA	GAZE / GESTURE	***Akhona looks at Debbie and indicates the first row of the grid***			

Time segment starts and ends	Transcript line number	Turn (* indicates start & end of critical event)	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
	229		KUHLE	GAZE	***Kuhle also looks at Debbie***			
7:16	230		MELLONY	SPEECH	Does she change it? ***[whispers to Debbie]***			
	231		DEBBIE	SPEECH	You see if you can work it out.	M statement		Directing (2a)
	232	31*	KUHLE	GESTURE	***Kuhle turns activity sheet towards herself***			
	233		DEBBIE	GESTURE	***Debbie turns sheet back into centre***			
	234		DEBBIE	SPEECH	Akhona, you just look at that for a second	M statement		Directing (2a)
	235		DEBBIE	SPEECH	***[To Kuhle]*** Come here. You put 13	M statement		
	236		DEBBIE	GESTURE	***Debbie indicates Kuhle's earlier answer on the corner of the activity sheet***			
	237		DEBBIE	SPEECH	***[To Akhona]*** You carry on. You just think about it			Directing (2a)
	238		DEBBIE	SPEECH	How did you get 13?	M question		Excavating (2b)
	239		KUHLE	SPEECH	I halved 26	L statement		
	240		KUHLE	GAZE	***Kuhle looks at Debbie***			
	241		DEBBIE	SPEECH	You halved 26.	M statement		Clarifying (2b)
	242		DEBBIE	SPEECH	Okay. Halved 26... Um, so would you change this now that you saw the way Akhona did it? Would that still be your answer?	M question		Excavating (2b)
	243	32*	KUHLE	EXPRESSION	***Kuhle shakes head very slowly***			
	244		KUHLE	SPEECH	No ***[very softly]***	L statement		
	245		AKHONA	EXPRESSION / POSTURE	***Sighs loudly and sits back in her chair***			
7:59	246		DEBBIE	SPEECH	So you would change it? Can you see what she did, because with your way um, didn't take those	M question M statement		Asking for reflection on what is seen (2b)
	247		DEBBIE	GESTURE	***Debbie indicates the circles in the 4th column***			
	248		DEBBIE	SPEECH	you didn't think about what that was did you? You took the whole thing, is that what I understand what you did?	M statement		Making actions explicit (2b)
	249		KUHLE	SPEECH	Yes ***[very softly]***	L statement		
8:09	250		DEBBIE	SPEECH	Okay, alright. Carry on then.	M statement		Directing (2a)

Time segment starts and ends	Transcript line number	Turn (* indicates start & end of critical event)	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
8:11	251		KUHLE & AKHONA	POSTURE	***Girls lean in together***			
	252		AKHONA	ACTION	***Akhona appears to work on the top row***			
	253	33	KUHLE & AKHONA	SPEECH	***They discuss quietly***			
8:18	254		KUHLE	ACTION / GAZE	***Kuhle starts counting on her fingers, glances at Debbie and continues***			
8:22 to 8:39					***Coffee discussion again***			
8:39	255		KUHLE	ACTION / GAZE	***Kuhle is still counting on her fingers, taking an occasional glance at Akhona***			
	256	34	AKHONA	POSTURE / GAZE	***Has her head in her hand, occasionally glances at Kuhle***			
8:49	257		KUHLE		***Kuhle stops counting***			
	258		AKHONA	GAZE / POSTURE	***Actively looking at the chart, moving to and fro in her chair***			
9:05	259		KUHLE	GESTURE / GAZE	***Points to the chart, and stares blankly into space***			
9:17	260		DEBBIE	SPEECH	What are you thinking girls? Akhona has got a plan has she?	M question		Probing (2b)
	261		AKHONA	SPEECH	Noo, I'll find the answer of here	L expressing something (in direct response to M question (260)		
9:25	262		AKHONA	GAZE / GESTURE	***Looking at Debbie and pointing to the clubs on the chart***			
	263	35	DEBBIE	SPEECH	Why are you starting on this column, this row?	M question	M attention caught by learner expressing something (261)	Probing (2b)
	264		DEBBIE	GESTURE	***Points to 2nd row***			
9:33	265		AKHONA	SPEECH	I want the answer of those, of those together	L expressing something (in direct response to M statement (263)	L attention caught by m question (263)	
	266		AKHONA	GESTURE / GAZE	***Points to the clubs and looking at Debbie***			
	267		KUHLE	POSTURE / GAZE	***Continues to sit back, pencil in mouth, staring at the ceiling***			

Time segment starts and ends	Transcript line number	Turn (* indicates start & end of critical event)	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
	268		DEBBIE	SPEECH	Okay			
	269		AKHONA	GAZE	***Looks at the chart***			
	270	36	KUHLE		***Silent***		Attention NOT caught	
9:38	271		KUHLE	ACTION	***Counts on her fingers***			
	272		DEBBIE	SPEECH	Kuhle, have you got an idea? Or were you just going with what Akhona thinks?	M question		Excavating (2b)
	273		KUHLE	SPEECH	Yes	L statement		
	274		KUHLE	GESTURE / POSTURE	***Still playing with pencil, elbows on the table***			
	275		KUHLE	ACTION	***Working on her paper***			
9:48	276	37*	DEBBIE	SPEECH	Maybe you could think of a different way?	M statement		Directing (2a)
	277		KUHLE	POSTURE / GAZE	***Stands slightly, leans over the chart, looking at Akhona's work***			
	278		DEBBIE	SPEECH	Let Akhona go her way and you think of another way that you could work it out	M statement		Directing (2a)
9:52	279		KUHLE	POSTURE / GESTURE /	***Sits, points pencil to top right of the chart, then reaches for a piece of scrap paper***			
	280		AKHONA	ACTION	***Continues to work***			
10:01	281		KUHLE	ACTION	***Starts to write on her paper***			
	282		AKHONA	GESTURE	***Occasionally references the chart, using pencil to point at it***			
10:14	283	38	KUHLE	POSTURE / EXPRESSION / GAZE	***Sits upright, makes a face, glances at Akhona's work briefly, rubs her chin, glances at Akhona***			
	284		AKHONA	EXPRESSION / POSTURE	***Big sigh, sitting back looking at her workings***			
10:26	285		AKHONA	POSTURE / GAZE	***Leans back into her work, glances at the chart***			
	286		KUHLE	ACTION	***Working on her paper again***			
10:33	287		AKHONA	GESTURE / GAZE / ACTION	***Points to top row of chart, looks at it intently, writes a number next to the club (could be a 6)***	L action		
	288	39	KUHLE	POSTURE / EXPRESSION	***Leans back, coughs, leans in***			
	289		AKHONA	ACTION / GAZE	***Begins to count on her fingers, looking at Debbie***	L action Eye contact L->M		

Time segment starts and ends	Transcript line number	Turn (* indicates start & end of critical event)	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
10:41	290		KUHLE	ACTION	***Counts on her fingers***	L action		
10:43	291	40	DEBBIE	SPEECH	Okay, if you think it's that	M statement	M attention caught by l action (287 & 289)	Directing (2a)
	292		DEBBIE	GESTURE	***Points to the number next to the club that Akhona wrote next to***			
	293		DEBBIE	SPEECH	Just test it with other places	M statement		
	294		DEBBIE	GESTURE	***Points to other clubs on the chart***			
	295		AKHONA	GAZE	***Looks at Debbie***	Eye contact L->M		
	296		DEBBIE	SPEECH	to see if it works	M statement		
	297		DEBBIE	SPEECH	So you said it might be 6			
	298		AKHONA	GAZE / EXPRESSION	***Continues to look at Debbie, grinning slightly***	Eye contact L->M		
	299		DEBBIE	SPEECH	So now try it in other places	M statement		
	300		DEBBIE	GESTURE	***Indicates the chart generally***			
	301		AKHONA	GAZE	***Looks at the chart***			
10:55	302		DEBBIE	SPEECH	Add them up and see if it is six Because that's how you test your idea	M statement		Directing (2a) Modeling (2b)
	303		AKHONA	GESTURE / POSTURE	***Points to 2nd row and leans into the chart***		L attention caught by m statements (299 & 302)	
	304		KUHLE	GAZE / EXPRESSION	***Keeps glancing at chart, sticks out her tongue, but doesn't write anything further on her paper***		Attention NOT caught	
11:05	305	41	AKHONA	ACTION	***Writes numbers next to the shapes on the chart, talking to herself as she does so***	L action	L attention caught by m statements (299 & 302)	
	306		AKHONA	GAZE / ACTION	***When she gets to the triangle at the end of the 2nd row, she references her workings, writes 8***			
	307		KUHLE	GAZE	***Continues to be silent but glances at the chart briefly***			
	308		AKHONA	POSTURE / ACTION	***Sits back, counts on her fingers***			

Time segment starts and ends	Transcript line number	Turn (* indicates start & end of critical event)	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
	309		AKHONA	SPEECH	8	Learner expressing something		
11:20	310		KUHLE	EXPRESSION / GAZE	***Has her thumb in her open mouth, looks at Debbie***			
11:26	311		AKHONA	EXPRESSION / GAZE	***Has an intake of breath, grins, looks at Kuhle***	Eye contact L->L		
	312		KUHLE	GAZE	***Looks at Akhona***	Eye contact L->L		
	313	**42**	AKHONA	GESTURE / EXPRESSION	***Gives a thumbs up and smiles broadly***	L gesture L expression		
	314		AKHONA	ACTION	***Continues to count on fingers***	L action		
11:33	315		KUHLE	GESTURE	***Plays with her fingers***		Attention NOT caught	
11:39	316		AKHONA	ACTION / POSTURE / GAZE	***Writes a total for row 1, sits back and looks at Debbie***	L action Eye contact L->M		
	317		DEBBIE	SPEECH	Does this one add up to 25?	M question	M attention caught by L->L eye contact, l gesture, l expression, l action, L->M eye contact (311-316)	Prompting (2b)
	318		DEBBIE	GESTURE	***Points to row 2***			
	319	**43***	AKHONA	SPEECH	Yes	L statement	L attention caught by m question (317)	
	320		AKHONA	GAZE	***Maintaining eye contact with Debbie***	Eye contact L->L		
	321		DEBBIE	SPEECH	Does it? Let's just do it.		M attention caught by l statement and by L->L eye contact (319-320)	Prompting (2b) Directing (2a)
	322		DEBBIE	GESTURE	***Grabs a pencil***			

Time segment starts and ends	Transcript line number	Turn (* indicates start & end of critical event)	Participant	Mode of social interaction	What is said and what is done	Catching Attention Mechanism	What happens after attention is caught	Mediating Practice
	323	44	DEBBIE	SPEECH	6 and 6 is..?	M question		Prompting (2b)
	324		DEBBIE	GESTURE	***Points to 2 clubs***			
	325		KUHLE	SPEECH	12	L expressing something in direct response to m question	L attention caught by m question (323)	
	326		AKHONA	SPEECH	12			
	327		AKHONA	GAZE	***looks up at Debbie***	Eye contact L->M		
	328	45	DEBBIE	SPEECH	And 8?	M question		
	329		DEBBIE	GESTURE	***Points to the club***			
	330		AKHONA	SPEECH	Is 16	L statement		
	331		DEBBIE	SPEECH	12 plus 8?	M question		
	332		AKHONA	POSTURE / GAZE	***Leans in and looks at Debbie***	Eye contact L->M	L attention caught by m question	
	333		AKHONA	SPEECH	12 plus 8 is ***[pause and looks at ceiling]***	L statement		
12:01	334		AKHONA & KUHLE	ACTION	***Both start to count on their fingers***	L action		
	335		KHULE	SPEECH	20	L expressing something in direct response to m question		
	336		KHULE	GAZE	***Looking at Debbie***			
	337		DEBBIE	SPEECH	20			

End of Episode Three
and
END OF APPENDIX I

APPENDIX J: Research question two – additional broad quantitative data

In this appendix I include the matrices that form the detailed quantitative data for section 6.4 in Chapter Six.

- Modes of social interactions for Episodes One, Two and Three
- Attention catching mechanisms for Episodes One, Two and Three
- Attention catching mechanisms summary
- Mediating practices for Episodes One, Two and Three
- Mediating practices summary

Modes of social interaction in Episodes One, Two and Three

Episode One (Elmtree Prep: Girls)

Table 48 below shows a matrix of the predominant modes of social interaction for each participant in Episode One the numbers shown are a count of the coded interactions. The second column shows that total interactions for each participant and subsequent columns show the break down by different modes.

Table 48: Matrix of predominant modes of social interactions in Episode One (Elmtree Prep: Girls)

Participant	***Total Interactions***	***Speech***	***Gaze***	***Posture***	***Gesture***	***Mathematical Action***	***Expression***
Anathi	**172**	54	33	23	20	11	31
Thembela	**179**	51	52	27	15	10	24
Debbie (Mentor)	**122**	83	2	3	28	6	0

Episode Two (Elmtree Prep: Boys)

Table 49 below is laid out in the same way as the previous one showing the predominant modes of social interaction for each participant in Episode Two.

Table 49: Matrix of predominant modes of social interactions in Episode Two (Elmtree Prep: Boys)

Participant	*Total Interactions*	*Speech*	*Gaze*	*Posture*	*Gesture*	*Mathematical Action*	*Expression*
Nate	**142**	26	43	22	19	12	20
Zac	**122**	34	34	9	16	16	13
Mellony (Mentor)	**102**	64	12	0	20	4	2

Episode Three (Luhlaza Primary: Girls)

Table 50 below is laid out in the same way as the previous two and shows the predominant modes of social interaction for each participant in Episode Three.

Table 50: Matrix of predominant modes of social interactions in Episode Three (Luhlaza Primary: Girls)

Participant	*Total Interactions*	*Speech*	*Gaze*	*Posture*	*Gesture*	*Mathematical Action*	*Expression*
Akhona	**171**	35	53	28	16	24	15
Kuhle	**127**	25	39	19	15	14	15
Debbie (Mentor)	**136**	94	1	0	38	2	1

Attention Catching Mechanisms in Episodes One, Two and Three

Episode One Two (Elmtree Prep: Girls)

Table 51 below details the predominant attention catching mechanisms coded for Episode Two. The first row of numbers are the coded instances for how learners' attention was caught and the second are the coded instances for the mentors' attention was caught. The three most prevalent mechanisms are shaded in each row.

Table 51: Matrix of Attention Catching Mechanisms for Episode One (Elmtree Prep: Girls)

	ATTENTION CAUGHT VIA …									
Attention Catching Mechanism	***Question***	***Statement***	***Learner expressing something***	***Gesture***	***Posture***	***Eye Contact***	***Task itself***	***Touch***	***Mathematical Action***	***Breath Emphasis***
Learners' attention caught by:	19	14	0	6	0	0	1	1	1	0
Mentor's attention caught by:	0	3	15	6	5	9	1	0	1	0
TOTALS	19	17	15	12	5	9	2	1	2	0

Episode Two (Elmtree Prep: Boys)

Table 52 below details the predominant attention catching mechanisms coded for Episode Two. The table is laid out the same way as the previous one.

Table 52: Matrix of Attention Catching Mechanisms for Episode Two (Elmtree Prep: Boys)

Attention Catching Mechanism	ATTENTION CAUGHT VIA ..									
	Question	*Statement*	*Learner expressing something*	*Gesture*	*Posture*	*Eye Contact*	*Activity*	*Task itself*	*Mathematical Action*	*Breath Emphasis*
Learners' attention caught by:	9	7	7	0	0	7	1	2	3	0
Mentor's attention caught by:	1	3	12	1	0	4	1	0	1	3
TOTALS	**10**	**10**	**19**	**1**	**0**	**11**	**2**	**2**	**4**	**3**

Episode Three (Luhlaza Primary: Girls)

Table 53 below details the predominant attention catching mechanisms coded for Episode Two. The table is laid out the same way as the previous two.

Table 53: Matrix of Attention Catching Mechanisms for Episode Three (Luhlaza Primary: Girls)

	ATTENTION CAUGHT VIA …									
Attention Catching Mechanism	*Question*	*Statement*	*Learner expressing something*	*Gesture*	*Posture*	*Eye Contact*	*Task itself*	*Touch*	*Mathematical Action*	*Breath Emphasis*
Learners' attention caught by:	5	7	0	1	0	2	0	0	0	0
Mentor's attention caught by:	0	1	5	1	0	2	0	0	6	0
TOTALS	5	8	5	2	0	4	0	0	6	0

Attention Catching Mechanisms Summary

In Table 54 below I have summarised the attention catching mechanisms across all three episodes. The table is split into verbal (light grey) and non-verbal (dark grey) ACMs. Verbal ACMs result from speech-based communication such as questions, statements and learners expressing something. Non-verbal ACMs result from all other forms of communication such as eye contact, gesture and so on.

Table 54: Summary table of ACM totals across all three episodes

	VERBAL ACMs			**NON-VERBAL ACMs**						
ACM	**Question**	**Statement**	**Learner expressing something**	**Eye Contact**	**Gesture**	**Mathematical Action**	**Posture**	**Touch**	**Task itself**	**Total ACMs**
Coded instances for all episodes	35	37	38	22	17	13	5	3	2	172
% of total instances	**20%**	**22%**	**22%**	**13%**	**10%**	**8%**	**3%**	**2%**	**1%**	100%
	64%			**36%**						

Mediating Practices in episodes One, Two and Three

Episode One (Elmtree Prep: Girls)

Table 55 (which is split into 2 parts for easier reading) summarises the predominant mediating practices coded in Episode One at Elmtree Prep. This episode has a total of 89 coded mediating practices.

Table 55: Matrix of mediating practices for Episode One (Elmtree Prep: Girls)

Level 1 - Environmental Provisions			**Level 2a - Funnelling** (Guide towards pre-determined solution)				**Level 2b - Reviewing** (Clarification of understanding)							
Encouraging	*Orienting or Setting the Scene*	*Inviting collaboration*	*Explaining*	*Telling*	*Directing*	*Funnelling*	*Modelling*	*Seeking justification*	*Probing*	*Prompting*	*Making actions explicit*	*Making talk explicit*	*Excavating*	*Clarifying*
11	3	1	3	0	2	0	3	5	7	17	7	11	0	3
15			5				50							

Level 2c - Restructuring (Taking understanding forward)			**Level 3 - Developing Conceptual Thinking**		
Promoting joint understanding	*Introducing / extending mathematical language*	*Rephrasing learner talk*	*Using Symbols*	*Connecting*	*Encouraging conceptual discourse*
6	3	2	6	1	1
11			8		

Episode Two (Elmtree Prep: Boys)

Table 56 summarises at the predominant mediating practices for Episode Two at Elmtree Prep. This episode has a total of 63 coded mediating practices.

Table 56: Matrix of mediating practices for Episode Two (Elmtree Prep: Boys)

Level 1 - Environmental Provisions			**Level 2a - Funnelling (Guide towards a predetermined solution)**				**Level 2b - Reviewing (Clarification of understanding)**					
Encouraging	*Orienting*	*Inviting collaboration*	*Explaining*	*Telling*	*Directing*	*Funnelling*	*Seeking justification*	*Probing*	*Prompting*	*Making actions explicit*	*Making talk explicit*	*Excavating*
13	1	1	3	1	6	2	2	2	4	6	5	2
15			12				21					

Level 2c - Restructuring (Taking understanding forward)	**Level 3 - Developing Conceptual Thinking**	
Promoting joint understanding	*Using Symbols*	*Connecting*
8	7	0
8	7	

Episode Three (Luhlaza Primary: Girls)

Table 57 summarises the predominant mediating practices for Episode Three at Luhlaza Primary. This episode has a total of 71 coded mediating practices.

Table 57: Matrix of mediating practices for Episode Three (Luhlaza Primary: Girls)

Level 1 - Environmental Provisions			**Level 2a - Funnelling** (Guide towards pre-determined solution)				**Level 2b - Reviewing** (Clarification of understanding)							
Encouraging	*Orienting or Setting the Scene*	*Inviting collaboration*	*Explaining*	*Telling*	*Directing*	*Funnelling*	*Modelling*	*Seeking justification*	*Probing*	*Prompting*	*Making actions explicit*	*Making talk explicit*	*Excavating*	*Clarifying*
3	1	2	3	0	22	7	2	0	6	8	5	1	3	6
6			32				29							

Level 2c - Restructuring (Taking understanding forward)			**Level 3 - Developing Conceptual Thinking**		
Promoting joint understanding	*Introducing / extending mathematical language*	*Rephrasing learner talk*	*Using Symbols*	*Connecting*	*Encouraging conceptual discourse*
0	0	0	3	1	0
0			4		

Mediating Practices Summary

With this focus on effective mediation and mathematics teaching, in Table 58 below I draw attention to the more *effective* mediating practices (levels 2b, 2c and 3) by using shading. The table gives a summary of the coded instances of mediating practices across all three episodes.

Table 58: Summary of mediating practice totals across all three episodes

Level of mediating practice	1 (Environmental)	2a (Funnelling)	2b (Reviewing)	2c (Restructuring)	3 (Developing Conceptual thinking)	Total
Total coded instances	36	49	**100**	**19**	**19**	223
% of total coded instances	16.1%	22.0%	**44.8%**	**8.5%**	**8.5%**	100%
	38.1%		**61.9%**			

END OF APPENDIX J

APPENDIX K: Mind map of constructs for this study

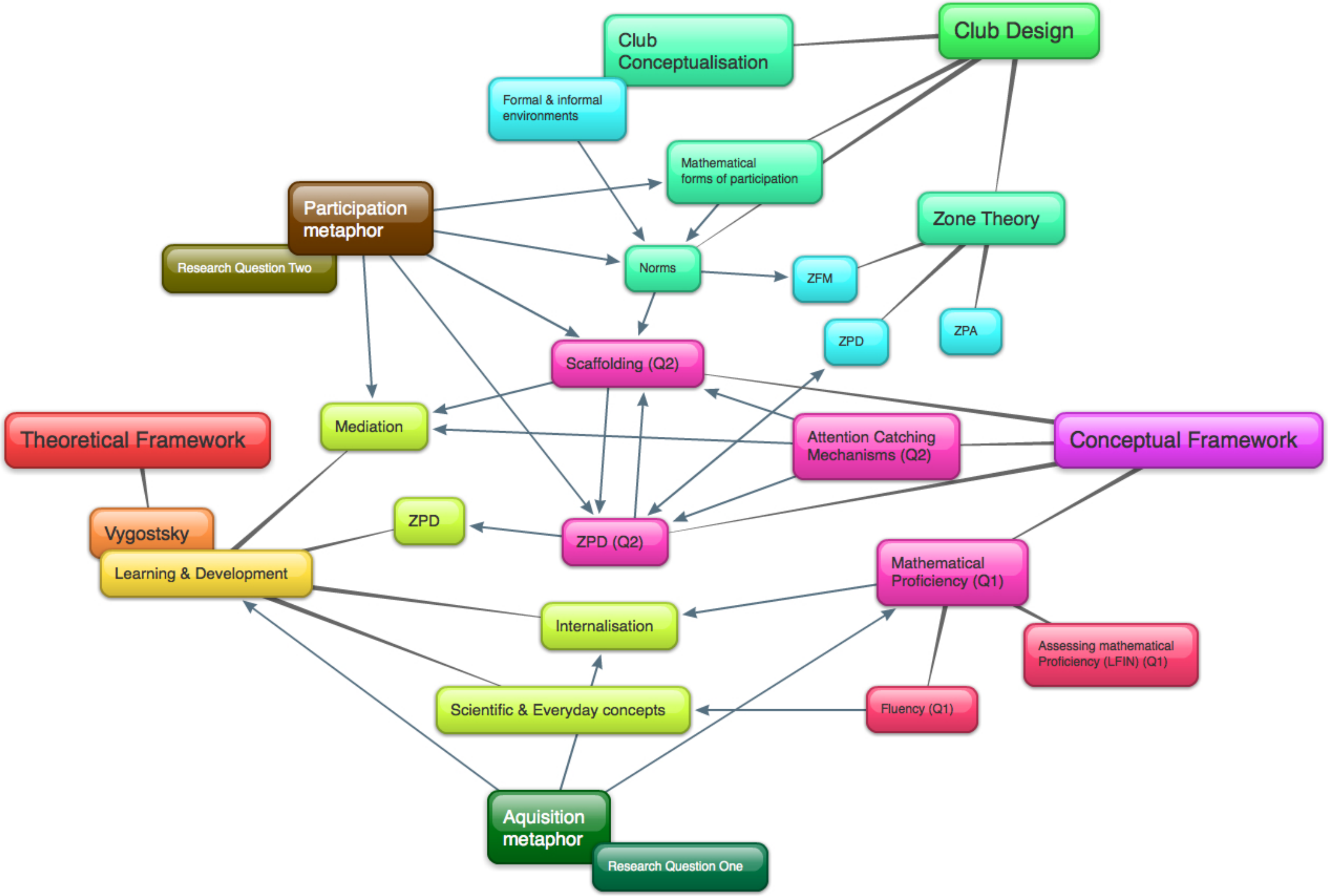

Figure 39: Mind map of constructs for this study

END OF APPENDIX K

APPENDIX L: Ethical items

Ethical clearance to work in schools for the clubs

Province of the
EASTERN CAPE
EDUCATION

STRATEGIC PLANNING POLICY RESEARCH AND SECRETARIAT SERVICES
Steve Vukile Tshwete Complex • Zone 6 • Zwelitsha • Eastern Cape
Private Bag X0032 • Bhisho • 5605 • REPUBLIC OF SOUTH AFRICA
Tel: +27 (0)43 702 7428 • Fax: +27 (0)43 702 7427/36 • Website: www.ecdoe.gov.za

Enquiries: Dr Heckroodt Email: bernetia@iafrica.com

26 September 2011

Prof Mellony Graven
SA Numeracy Chair
Education Department
Rhodes University
PO Box 94
GRAHAMSTOWN
6140

Dear Prof Graven

PERMISSION TO UNDERTAKE A STUDY: THE NUMERACY INQUIRY COMMUNITY OF LEADER EDUCATORS (NICLE) AND THE NUMERACY LEARNER CLUBS PROGRAM

1. Thank you for your application to conduct research.
2. Your application to conduct the above mentioned research in fifteen (15) Primary Schools in the Eastern Cape under the jurisdiction of the Grahamstown District is hereby approved on condition that:
   a. there will be no financial implications for the Department;
   b. institutions and respondents must not be identifiable in any way from the results of the investigation;
   c. you present a copy of the written approval letter of the Eastern Cape Department of Education (ECDoE) to the District Directors before any research is undertaken at any institutions within that particular district;

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building blocks for growth

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Ilizwe eliqaqambileyo!

d. you will make all the arrangements concerning your research;

e. the research may not be conducted during official contact time, as educators' programmes should not be interrupted;

f. should you wish to extend the period of research after approval has been granted, an application to do this must be directed to the Director: Strategic Planning Policy Research and Secretarial Services;

g. the research may not be conducted during the fourth school term, except in cases where a special well motivated request is received;

h. your research will be limited to those schools or institutions for which approval has been granted;

i. you present the Department with a copy of your final paper/report/dissertation/thesis free of charge in hard copy and electronic format. This must be accompanied by a separate synopsis (maximum 2 – 3 typed pages) of the most important findings and recommendations if it does not already contain a synopsis. This must also be in an electronic format.

j. you are requested to provide the above to the Director: The Strategic Planning Policy Research and Secretarial Services upon completion of your research.

k. you comply to all the requirements as completed in the Terms and Conditions to conduct Research in the ECDE document duly completed by you.

l. you comply with your ethical undertaking (commitment form).

m. You submit on a six monthly basis, from the date of permission of the research, concise reports to the Director: Strategic Planning Policy Research and Secretariat Services.

3. The Department wishes you well in your undertaking. You can contact the Director, Dr. Annetia Heckroodt on 043 702 7428 or mobile number 083 271 0715 and email: annetia.heckroodt@edu.ecprov.gov.za should you need any assistance.

Dr AS HECKROODT

DIRECTOR: STRATEGIC PLANNING POLICY RESEARCH AND SECRETARIAT SERVICES

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Ikamva eliqaqambileyo!

Parental consent letters

SA Numeracy Chair After-School Maths Clubs
Education Department, Rhodes University, PO Box 94, Grahamstown, 6140

SA NUMERACY CHAIR

Informed Parental Consent Form for Grade 3 Learners participating in After-School Maths Clubs and research related to these clubs

Dear Grade 3 Parent

Monday, August 08, 2011

We will be running after-school Maths clubs at your child's school. The clubs will be fun places where we will provide ways to support your child's maths learning. We invite them to come and learn. We will also be researching how they learn. In the clubs, your child may be part of a focus group, may be interviewed, observed at what they do and may be included on video and voice recordings. We are running these clubs because South Africa needs confident learners who feel they can do maths so that they are able to go on and study mathematics in their further education and, more importantly, who are able to use maths in their everyday lives.

During the Maths Clubs, your child will be involved with mathematical activities and mathematical work. The clubs will run once a week during term time for about 1 hour and 15 minutes at your child's school.

All the data recorded is confidential and no one else except Debbie Stott and Mellony Graven will have access to the raw data collected during the research. The data will be kept **confidential** and will be stored in a safe place. During and after the study, we may also publish some of the results of the research in order that other interested people may learn from it. Any information used about your child in publications will have a number or pseudonym on it instead of his/her name. Your child will NOT be asked to talk about any personal information about themselves or their home lives.

Neither you nor your child will be provided with any payment to take part in the Maths Clubs or the research. However, she/he will be given refreshments during the club session.

You are welcome to come to the 1st Maths Club workshop so that you can see how the club works. You will be informed of the date for this closer to the time.

You do not have to agree that your child will join the Maths Club and take part in the research. Before you decide, you can talk to anyone you feel comfortable with or come and talk to us in the 1st session if you prefer. If you have any questions, please contact: Debbie Stott - 083 376 2255 or Mellony Graven - 046 603 7268 during office hours.

Kind regards

Debbie Stott & Mellony Graven
SA Numeracy Chair at Rhodes University

Page 1 SANC Maths Clubs 2011

I agree voluntarily for my child to participate in the Maths Club sessions AND in the research study

Name of Child											Print Name of Parent or Guardian	
Date	D	D	/	M	M	/	Y	Y	Y	Y	Signature of Parent or Guardian	

APPENDIX M: Promoted activities in the clubs

Table 59: Promoted Activities (ZPA) in the clubs

<table>
<tr><th colspan="3">PROMOTED ACTIVITIES</th></tr>
<tr><th>LFIN ASPECT[51]</th><th>ELMTREE PREP</th><th>LUHLAZA PRIMARY</th></tr>
<tr><td>A: Structuring numbers 1 to 20</td><td>No specific focus</td><td>Mental, individual, pair and group activities to strengthen number combinations to 10 and 20.</td></tr>
<tr><td>B: Number words and numerals</td><td>No specific focus</td><td rowspan="2">Use of Flard Cards (Arrow Cards) to strengthen number recognition of 2, 3 and 4-digit numbers and for building conceptual place value. Mental activities and games designed to develop incrementing and decrementing on and off the decuple and through 100 up to 1000.</td></tr>
<tr><td>C: Conceptual place value (ability to reason in terms of 10s and 1s)</td><td>Mental activities and games designed to develop incrementing and decrementing on and off the decuple and through 100, 200 and 1000.</td></tr>
<tr><td>D: Addition and subtraction to 100</td><td>Mental facility and development of strategies for working with numbers to 100 (and over) that did not rely on using the standard vertical algorithms. For example, number talks[52], SCOOT game etc.</td><td>Mental facility and development of strategies for working with numbers to 100 that did not rely on using the standard vertical algorithms.</td></tr>
<tr><td>E: Early multiplication and division</td><td>Array based activities to develop multiplicative reasoning (2nd half of the year).</td><td>No specific focus but promoted mental activities involving skip counting of multiples of 2s, 3s, 5s, 10s and 100s.</td></tr>
<tr><td>Other mathematical skills such as logical thinking, justification</td><td>Number talks and general club norms. Logic puzzles and games that promoted logical thinking (2nd half of the year).</td><td>No specific focus except through establishing club norms, one of which is to explain thinking.</td></tr>
</table>

[51] These are the Learning Framework in Number Aspects used to analyse the collected data. For detail, see Methodology Chapter.

[52] A classroom conversation and discussion around purposefully crafted computational problems that are designed to elicit specific strategies that are focused on number relationships and patterns. During number talks, learners communicate their thinking when presenting and justifying solutions to problems they solve mentally. These exchanges lead to the development of more accurate, efficient, and flexible strategies (Parrish article, 2011).

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GLOSSARY

Glossary of key terms as used in this study.

A

After school maths clubs: See SANC project after school maths clubs.

Attention catching mechanisms (ACM) can be thought of as ways that the participants catch each other's attention and communicate mathematical ideas and reasoning to each other and they are of particular interest because they often lead to the emergence of a ZPD

E

Elements of fluency include basic facts and knowing basic methods. Learning to be fluent should be intertwined and developed along with sense making and flexible thinking and should be taught using an interwoven approach.

L

Learning and development are a dialectical unity in which learning leads development. Learning cannot exist without development and development cannot exist without learning. The process of development is not a direct and natural process, but rather indirect, artificial, mediated (governed) by cultural laws of teaching-learning. Learning awakens a variety of internal development processes that are able to operate only when the child is interacting with people in his environment and in cooperation with his peers. Learning is a necessary and universal aspect of the process of developing culturally organised, specifically human, psychological functions.

Learning Framework in Number (LFIN) The LFIN framework is a powerful tool for profiling an individual club learner's mathematical proficiency across the range of the key mathematical aspects.

M

The *MR programme* is made up of three main components: the Learning Framework in Number (LFIN), the one-to-one assessment interview and a teacher framework.

Mediation is a form of intervention that focuses on experiences during the process of thinking and learning and refers to use of cultural tools (or signs) to bring about qualitative changes in thinking.

Mathematical proficiency is the ability to process, communicate and interpret numerical information in a variety of contexts overlaid with strands of numeracy proficiency: understanding numeracy concepts, computing fluently (practically, mentally and procedurally), applying concepts to solve problems (in creative and inventive ways), reasoning logically (in creative and inventive ways) and engaging with mathematics – seeing it as sensible, useful and do-able (enjoyment and passion)

S

SANC project after school maths clubs. Informal, after school clubs focused on developing a supportive learning community where learners' can develop their mathematical proficiency make sense of their mathematics and where they can engage and participate actively in mathematical activities. Individual, pair and small group interactions with mentors are the dominant practices with few whole class interactions.

Scaffolding refers to the ways in which mentors create the learning environment in the club and take action to help students learn (construct, deepen, solidify, and consolidate learning). Learning in the ZPD and using the mediating means of scaffolding includes setting up the physical and social structures for engagement, providing challenges and responsive support, and developing conceptual thinking (Anghileri 2006).

Z

ZPD. My articulated notion of the ZPD indicates that a ZPD does not exist prior to the learning activity and is created (or not) through the social interactions with others during club activities. Its emergence depends on the active contributions of the learners as well as the mentor. The ZPD is as a symbolic space that encompasses the whole person. The emergence of a ZPD is encouraged by presenting activities that are meaningful to the learner, activities that can be accomplished with assistance, ones that allow the learner agency to benefit and take advantage of the assistance from others. The learning activity is the focus for analysis and includes the task, the ethos of the club and the possible ways that the participants may interact in that moment.

Zone Theory. Used as a design framework for the clubs (empirical field for this study) and as an explanatory tool, Zone Theory describes the structure of the developing club learners' environment and the relationships between the learner and the other people in the environment. It assists with a better understanding of how the ZPD operates in a specific learning context and creates a picture of the physical and cultural space in which the ZPD is situated. The zones are dynamic, interrelated constructs which interactively generate the environment in which the learner develops.

INDEX OF KEY TERMS