Investigating the nature of grade six after school mathematics club learners' shifts in mathematical number sense and procedural fluency

A full Thesis submitted in fulfilment of the Requirements of the Degree of

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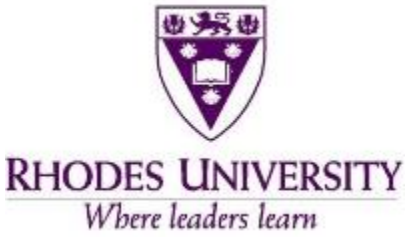

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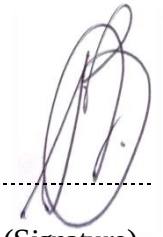
Declaration of original authorship

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, this thesis contains no material previously published or written by another person except where due reference is made.



(Signature)

18 March2019

(Date)

Dedication

I would like to thank the Almighty God for providing me with the opportunity and strength for completing this study.

I am fully obligated to my supervisor, Dr. Deborah Ann Stott and co-supervisor, Prof. Mellony Graven for their commitment and guidance during my studies. Indeed, it was tough, but their endless support turned it into a pleasant one.

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Whilst undertaking this research study I was able to run workshops on how to develop and run afterschool maths Clubs to Senior Education Specialist and teachers of mathematics in the Senior, Intermediate and Foundation Phases in the Eastern Cape

During the completion of this venture, I was also able to present papers at conferences, publish my work in journals and learn the skill of writing long and short papers:

- **Stott**, D., **Graven**, M., **Baart**, N., **Hebe**, G., & **Mofu**, Z. (2017). After school maths Clubs: Investigating learner progression in an expanding intervention model. *In Proceedings of the 23rd Annual National Congress of the Association for Mathematics Education of South Africa* (pp. 313–324). Port Elizabeth: AMESA.
- **Stott**, D., **Graven**, M., **Baart**, N., **Hebe**, G., & **Mofu**, Z. (2017). Percentage scores from all PfP Programme Clubs across districts. Bloemfontein, SAARMSTE 2017 symposium paper.
- **Stott**, D., & **Baart,** N. (2018). Visualising grade 6 after-school mathematics club learners shifting mathematical proficiency along a spectrum of progression**.** In L. Webb (Ed.), *Proceedings of the 26th Conference of the Southern African Association for Research in Mathematics, Science and Technology Education* (SAARMSTE) (pp. 195–199). Gaborone, Botswana: SAARMSTE.
- **Stott**, D., **Baart**, N., & **Graven**, M. (forthcoming). Illuminate how partnerships between academics, district officials and teachers can enable powerful student learning in the club space. *We argue that within the tightly focused development Programme run by teachers in this one district, it is possible for learners to make substantive progress in mathematical proficiency (especially procedural fluency and conceptual understanding) when comparing scores and learner methods between a pre- and post- assessment*. **AER Journal Article forthcoming.**

Abstract

A wide range of research locally points to intermediate phase learners having extremely weak basic number sense resulting in the dominance of inefficient strategies for calculations with the four operations, irrespective of the number range. The grade six Annual National Assessments (ANA) diagnostic reports for 2012 to 2014 also point to errors and misconceptions that tend to dominate learners' computations in the four basic operations; such errors are often attributed to the use of either tallies or incorrectly applied mathematical procedures.

Having the above context in mind and following informal conversations with teachers in the Uitenhage Education District, five teachers expressed an interest in running the afterschool mathematics clubs based on the South African Numeracy Chair (SANC) project model. The SANC project team ran workshops in April, May and June 2016 with nine teachers (five as facilitators and four others as co-facilitators in five different club sites) in which teachers were provided with key resources for use in their clubs. Fifteen club sessions ran in each club with grade six learners across the 2nd and 3rd terms.

These clubs form the empirical field for this research, which aims to investigate the nature of learners' evolving number sense, procedural fluency and teachers' experiences of working with learners in the club space. The unit of analysis in this study is both the shifts evident in learners' number sense and procedural fluency as a result of participating in the clubs and the teacher's experiences of working with learners in those clubs as club facilitators.

A social constructivist perspective of learning guides this study. Especially Vygotsky's (1978) notion that cognitive development stems from social interactions and guided learning within the Zone of Proximal Development (ZPD) of children, guided by more knowledgeable others. Furthermore, Kilpatrick et al.'s (2001) strands of mathematical proficiency provide the conceptual frame with a particular focus on procedural fluency and number sense.

A mixed method approach to data collection was used. Quantitative data has been drawn from learner's scores on pre- and post- assessments on four basic operations. Visual progression spectra have been adopted from the Pushing for Progression (PfP) Programme which is an intervention Programme developed by the SANC project for club facilitators. They provide explanations of learner progression trajectories and how to analyse learner methods. Qualitative narratives were drawn from learner progression data, as well as teacher post club questionnaires and one-to-one teacher interviews.

The findings of this research suggest that learner workings when used in conjunction with visual progression spectra can provide important clues to researchers and teachers. This in turn contributes to an understanding of where learners are in their mathematical learning and gives ideas for how to support learners to progress using more flexible methods of calculation, particularly for poor performing learners. Included, is the discussion of the effectiveness of the club space to enable such shifts and improve learner flexibility, fluency and performance as displayed in learner methods and scores of the pre- and post-assessments. The teachers' observations about the relaxed atmosphere in the club space, small sized groups, learning through play with co-members may have enabled the shifts in procedural fluency and number sense in club learners. Additionally, implications of the study are discussed, and tentative recommendations are made for the DBE to consider.

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List of Acronyms

AMESA:	Association for Mathematics Educators of South Africa
ANA:	Annual National Assessments
CA:	Curriculum Advisor
DBE:	Department of Basic Education
ECPDE.:	Eastern Cape Provincial Department of Education
EGMA:	Early Grade Mathematics Assessment
FET:	Further Education and Training
GET:	General Education and Training
IPCAPS:	Intermediate Phase Curriculum Assessment Policy Statements
ISP:	Intermediate and Senior Phases
LoLT:	Language of Learning and Teaching
MECI:	Mathematics Education Chairs Initiative
NPPPR:	National Policy Pertaining to the Programme and Promotion Requirements
NS:	Number Sense
OSVs:	Onsite Support Visits
PF:	Procedural Fluency
PfP:	Pushing for Progression
SA:	South Africa
SANC:	South African Numeracy Chair
SACMEQ:	South African Consortium for Monitoring Educational Quality
SES:	Senior Education Specialist
TIA:	Tailored Independent Activity
TIMSS:	Trends in International Mathematics and Science Study

TMU: Teaching Mathematics for Understanding

CHAPTER 1: ORIENTATION TO THE STUDY

1.1 Introduction

In this opening chapter I provide an outline of this research study. I begin by highlighting the context of mathematics education in South Africa. Encompassed in this context is the problem situation to be addressed, the role of the South African Numeracy Chair (SANC) project and the Pushing for Progression (PfP) Programme in pursuit of addressing such problem situation and the nature of the afterschool mathematics clubs as an intervention. Then I deliberate on the rationale, significance and potential value of the research. Finally, I present the research goals, questions and the outline of the rest of the chapters of the thesis.

The overarching drive of this enquiry was to investigate the nature of the shifts in Grade 6 learners' procedural fluency and number sense when participating in afterschool mathematics clubs and the teachers' experiences of working with club learners in the club space. The afterschool mathematics clubs ran over 15 weeks as part of the PfP development Programme offered by the SANC project. What this project is and what is envisioned in it will be deliberated on later in this chapter. In the next section I discuss the context of mathematics education in South Africa.

1.2 Southern African Mathematics Education Context

South Africa is significantly underperforming in mathematics education at both primary and secondary levels. The condition of mathematics education in South Africa has often been described as being in crisis (Fleisch, 2008). Currently learners are unable to move their thinking sufficiently forward from concrete counting to abstract thinking (Graven and Stott, 2016). Poor quality of mathematics teaching, teacher knowledge, language, opportunities to learn, teaching time, home resources, and learner dispositions have been cited among other reasons as the cause of these challenges we are faced with in South Africa. Hence there is a need to strengthen in-service training of mathematics teachers and learner achievement in mathematics (Carnoy et al., 2008; Heyd-Mezuyanim and Graven, 2016; Hoadley, 2012; Reddy, 2006; Spaull, 2013).

It has been reported by the Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ) (Moloi & Strauss, 2005) that our South African learners are not competent in computing and manipulating numbers and general mathematics concepts when compared with both international and regional countries. SACMEQ includes fifteen Ministries of Education in Eastern and Southern African Countries. Its mission is to assist educational planners and researchers to undertake studies of

the quality of their education systems by working in a cooperative manner that encourages them to share their experiences and to learn from each other.

As a member of SACMEQ, South Africa upholds the values and shares the goals of the Consortium. South Africa could not participate in SACMEQ I in 1995. However, when the opportunity presented itself in 2000, South Africa seized it and participated in SACMEQ II and later participated in SACMEQ III and IV between the years 2000 and 2013.

The last two surveys conducted by SACMEQ, highlighted that South African learners performed below the poorer African countries such as Kenya, Tanzania and Swaziland (Spaull & Kotze, 2015). South Africa's overall performance in Rasch Scores in SACMEQ IV was 552 in mathematics and for the first time achieved above the mean SACMEQ score of 500. Despite South Africa making such improvement, less learners achieved higher mathematics competency levels and could cope with questions of higher cognitive demand (DBE, 2017). Further improvement is said to be possible if the South African education sector can strengthen in-service and pre-service training of teachers with respect to pedagogical and subject content knowledge in order to equip the learners with these skills (DBE, 2017).

Furthermore, the 2012 to 2014 Annual National Assessments (ANA) results reflected that learner performance in mathematics worsens in Grade 6 (DBE, 2014 p.92). In the same report it was revealed that in the Eastern Cape province, Grade 6 learners achieved below 40% (DBE, 2014). This situation is reflected in the Uitenhage District where this study was carried out and the results for this district are shown in the graph below.

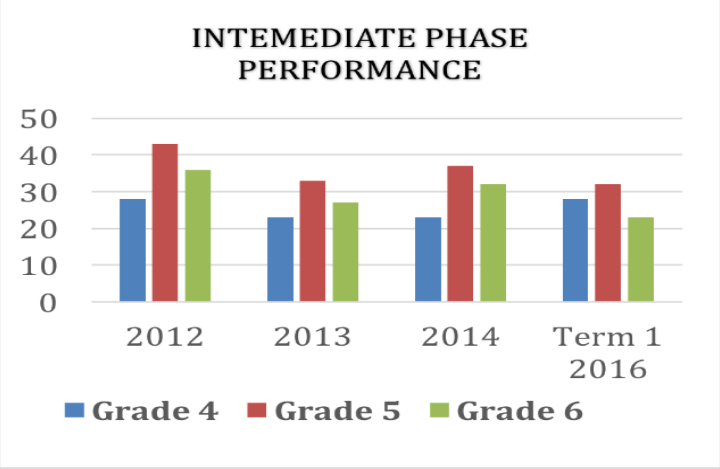


Figure 1: Uitenhage district ANA 2013 – 2014 learner results & 2016 (Term 1) learner performance

The graph in Figure 1 above, shows the performance of the grade 6 learners that are being investigated in this study but also performance of the grades four and five learners as well. The purpose of that is to show that Grade 4 learners also have low marks. The situation seems to improve in grade five but worsens again in Grade 6 in all these years stipulated above. This 2012 – 2014 ANA results report mentions that 16% of Grade 3 learners have performed at a Grade 3 level in mathematics. Meaning that even at grade 3 level the vast majority are under performing in mathematics (DBE, 2014). Consequently, the problem of poor performance in mathematics seem to begin in the foundation phase and spills over to the intermediate phase.

1.2.1 The Problem

Spaull and Kotze (2015) support the view above and in their research, they have proven that the root cause of these problems lies in the foundation phase and intensifies to the senior phase, later in the further education and training (FET) band up to higher institutions of learning. Other researchers even, claim that learners are promoted up the grades without having all the mathematics content and foundational proficiencies of the preceding grades. This the result of having large cognitive backlog and learning dispositions that inhibit more complex future learning (Carnoy, Chisholm & Addy, 2012; Schollar, 2008). This is mostly apparent when Grade 6 learners still use tally marks, circles and modelling to calculate one to three-digit operations (DBE, 2014). That indicates that such learners do not have number sense and are not fluent in the foundational mathematics they will need for higher level of their schooling and as expected and required by the mathematics curriculum prescribed for Grade 6.

What could be the cause of the claims cited above has been a concern for the mathematics teachers I work with. I am currently a Senior Education Specialist (SES) and curriculum/subject advisor for mathematics in the General Education and Training (GET) band for the Intermediate and Senior Phases (ISP) under the Curriculum Management and Support directorate of the Eastern Cape Province in South Africa. I work with mathematics teachers in these two phases. They often complain that they are not able to complete and cover the prescribed curriculum due to the fact that the prescribed content and assessment requirements in the curriculum assessments policy statements (CAPS) is too heavy and this leads to a lack of content consolidation and revision with the learners. I have experienced this during the onsite (school and classroom) support visits (OSVs) and attest that when the curriculum content is heavy teachers have no time to teach reasoning skills and application to everyday situations, which in turn leads

to learners thinking rigidly, rather than applying flexible and fluid knowledge to their mathematics learning.

Apart from the opportunities to consolidate and revise the work covered, I believe that learners should first have an opportunity to make sense of the content they are taught. Meaning that the teacher should have time to provide a platform for sense making, concept building, reinforcement, scaffolding then consolidation, practise and revision. When too much content has to be covered within the same year there will be less or no opportunities for the above.

Additionally, mathematics teachers in SA, report on the mathematics content covered monthly as a way to control and monitor under teaching and non-completion of the prescribed content for a particular grade in a year. Teachers attest that they tend to rush regardless of whether the learners understand or make sense of the content covered in order to comply. As a result, learners proceed to the next grade with content gaps, misconceptions and backlogs, which contribute to underperformance, lack of mathematical proficiency, low attainment and achievement in mathematics.

In South Africa there have been numerous initiatives such as to support and monitor mathematics education. Examples include: "How I teach", "One plus four", analysis of results, addressing errors and misconceptions in mathematics, Sasol Inzalo's methodology, and many more. Unfortunately, the picture that emerges is dire and consistent (Spaull, 2012). Many interventions aimed at improving learner attainment by Department of Basic Education (DBE) and the Eastern Cape Provincial office known as department of Education (DoE) are in the form of lecturing style workshops. They are run afterschool when the teachers are tired after a day of teaching. Teachers as participants in such workshops are provided with little or no time for a hands-on approach and engagement with shared activities due to time constraints and sometimes transport issues.

Among other duties that I am entrusted with as the subject/curriculum advisor is to come up with strategies that could improve the problem situation and challenges cited above, and to aid and support teachers. In this context of low participation and performance by learners, I have decided to explore whether the afterschool mathematics clubs as part of the PfP Programme offered by the SANC project could be used as an initiative to address some of these challenges. I approached the SANC project and later implemented the Pushing for Progression (PfP) Programme afterschool mathematics clubs and teacher development as an intervention. Now, I give an overview of the SANC project.

1.2.2 The South African Numeracy Chair (SANC) project

The Mathematics Education Chairs Initiative (MECI) was established in 2010 in which six university academics were appointed to research Chairs in South Africa. The principal goals of the MECI initiative is to improve mathematics teaching and learning in schools, to broaden participation and improve performance in mathematics for improved economic competitiveness and wider social development. The rationale underpinning this initiative is for the Chairs to improve mathematics teaching and learning in the public schooling system through a close partnership with a selection of schools for the duration of their projects (MECI, 2018).

The SANC project, situated at Rhodes University in the Eastern Cape of South Africa, is one of two such numeracy chairs. Through their research and development projects, the team investigated different aspects of the problem to explore solutions, and produced different Programmes or courses and materials, 1which can be shared and taken up by others in similar contexts.

Among other goals they focus on training and development for practicing (in-service) teachers to improve the quality of their teaching; to improve the mathematics results in schools; to research sustainable and practical solutions to the mathematics challenges in the country; and to provide leadership on mathematics education and increase dialogue around the solutions (MECI, 2018).

One of the key objectives of the SANC project is to support the learners to make sense of numbers and to progress them from using inefficient and constrained methods of calculations to more fluent and flexible methods through after school club activities. This push towards increasingly efficient methods of computing in mathematics and number sense is the central aspect of the project's Pushing for Progression Programme which is also a teacher development Programme. I will now provide an outline of the Pushing for Progression teacher development Programme.

1.2.3 The Pushing for Progression teacher development Programme

The PfP Programme is a 15-week Programme (see Chapter Two for the timeline of the afterschool math Clubs) which aims to provide support for teachers to run weekly afterschool mathematics Clubs in their schools. The Programme aims to develop learner sense making in numbers, shifting learner mathematical fluency from being passive learners to becoming active participants in their mathematics learning (South African Numeracy Chair Project, 2016). Teachers have three workshops sessions with the SANC project team members taking them through the resources and activities that will been done during the afterschool mathematics Club sessions.

1.2.4 The nature of the afterschool mathematics Clubs

The afterschool clubs as part of the PfP aim to support participating teachers to progress their club learners from concrete to more efficient methods of calculation and to make sense of numbers by offering activities in a more actively engaged and informal environment. As learners participate in the club activities they are encouraged to talk about their thinking, share their ideas and strategies while solving mathematical problems. Furthermore, through clubs, learners spend more time working on mathematics as they spend an hour per week in the clubs and at home using their take home books.

1.2.5 The PfP teacher development Programme in my District

As I indicated earlier, I wanted to explore if mathematics clubs could be a productive space to progress learners' mathematical proficiency and number sense when clubs were run by teachers rather than by SANC project team members. In my role, as subject advisor, I argued for running the PfP Programme in five of the schools in my district where teachers showed interest and wanted to know more about how the clubs could work in their schools. I presented the rationale to my colleagues in the DoE and ran an information workshop for the principals and teachers of the five schools. All stakeholders expressed interest and willingness to participate in the programme.

Thus, the SANC project offered this PfP Programme to my district and ran workshops in April, May and June 2016 with the five schools. These workshops focused on the use of focused activities and games (using playing cards and dice) to develop mathematical proficiency and positive learner learning dispositions. Teachers were provided with an overview of club aims and pedagogical principles, key resources, mathematics fluency games and sets of take-home learner workbooks for use in their clubs.

Following the first workshop, teachers began running clubs once a week for an hour each session after school. Fifteen club sessions took place at each school across the 2nd and 3rd terms of 2016. The teachers invited interested learners from the bottom half of the performance spectrum to attend (learners attaining below 30% in mathematics). SANC project sought parental permission for learners to participate in the clubs and for their progress to be recorded and provided teachers with assessment activities as part of their broader data collection activities for the PfP Programme. Although the clubs ran independently and prior to the start of my research, learner progression and teacher experiences in these clubs are the focus for my research. The rationale, significance and potential value of this research is discussed below.

1.3 Rationale, significance and potential value of the research

As stated earlier, research locally points to intermediate phase learners having extremely weak basic number sense resulting in the dominance of inefficient, one to one counting-based strategies for calculations in the four operations. The diagnostic reports produced after the administration of grade six ANA 2013 to 2014 also point to errors and misconceptions that tend to dominate learners' computations for the four operations. They attribute such errors to the use of either tallies, repeated addition-based strategies or incorrectly applied procedures (DBE, 2014 & DBE, 2015).

Since the PfP Programme is specifically aimed at developing number sense and mathematical proficiency in club learners and given that the PfP Programme has now expanded across four provinces, it is useful to research whether learners can progress mathematically in clubs when the clubs are run by teachers and not by the SANC project team. My research aims to explore whether participation in clubs such as these can promote shifts in learners' number sense and procedural fluency. While such shifts have been established in clubs run SANC project they have not been researched when run by teachers except for one study by Hebe (2018).

1.4 Research goals and questions

The predominant goal for this research is to investigate if the clubs can be a productive learning space for learners when the clubs are run by teachers. Therefore, this research aims to explore two main aspects: the nature of learners' changing mathematical proficiency (specifically procedural fluency) and number sense as a result of participation in after school clubs and how these might evolve through club participation; and teachers' experiences of working with learners in these club spaces. The unit of analysis in this study is therefore both the learners (in terms of changing mathematical proficiency) in the clubs and the teacher facilitators experiences of working with learners in those clubs. In this respect I note that the focus here is not on teacher performance or impact the clubs have in their classroom.

The research questions are:

1. What changes are evident overtime in learners' number sense and procedural fluency through club participation?
2. What are teachers' experiences of learners' changing number sense and procedural fluency as a result of participating in the clubs?
3. What are teachers' experiences of working with learners in the club space?

1.5 Overview of the research methodology

An interpretive research paradigm was used for this enquiry since it is argued that interpretivists look for meaning in the subjective experiences of individuals engaging in social interaction (Miller, 2004). According to Creswell (2013) an interpretive framework allows individuals to understand their world and develop their own meanings that correspond with their experiences. I take that to mean that teachers and learners in the club space are individuals engaging and interacting socially to experience and develop their own meaning of mathematics learning in that particular space. In a social constructive approach, the focus tends to shift from the teacher to that of the learners hence the club members are not regarded as empty vessels to be filled but a space where they are urged to be actively involved in their own process of learning.

1.6 Thesis outline

This thesis consists of five chapters and a number of appendices. In Chapter One I introduce the South African mathematics education context, the problem, the role of the SANC project, the rationale, significance and potential value of the study. I presented the research goals, questions and overview of the research methodology.

In Chapter Two, I return to review the South African context in more detail, review literature that is relevant to the study's theoretical and conceptual frames. In Chapter Three, I detail the research design and methodology. In Chapter Four I present the findings. In Chapter Five, I summarise the main results and finally discuss the main issues in the literature and link up with the key findings of Chapter Four.

In the next chapter, I will review literature relevant to the study and explore the theoretical foundations for this study.

CHAPTER 2: LITERATURE REVIEW AND THEORETICAL FRAMING

2.1 Introduction

The previous chapter provided an outline of this research study. In this chapter I present a review of the literature that is relevant for this study by reviewing the South African context in more depth and discussing the theoretical and conceptual frameworks underpinning this thesis. Finally, I detail the conceptual tools that are contained in my research questions and which will be used for the analysis of my findings later in the thesis.

2.2 Mathematics Education in the South African context

As stated in the Introduction chapter, mathematics education at both primary and secondary levels in South Africa is significantly underperforming. The Trends in International Mathematics and Science Study confirms that South African learners did not achieve well in mathematics (TIMSS, 2003, & 2007). Several researchers (Fleisch, 2008; Moloi & Strauss, 2014; Spaull & Kotze, 2015; Graven & Stott, 2016) have argued that learners in South Africa are still bound by one-to-one counting strategies or use procedures they do not understand. Schollar's (2008) extensive study showed that learners tend to use inefficient counting strategies and error prone procedures.

The two consecutive SACMEQ (II and III) reports indicated that our learners are not competent in computing and manipulating numbers and general mathematics concepts. As a result, they have performed below the required standard when compared with other African Countries (Spaull, 2007). As much as it is in the SACMEQ IV report that South Africa has achieved above the mean score of 500, less learners achieved higher competency levels and could cope with questions of higher cognitive demand (DBE, 2017).

Research shows that early intervention Programmes can be effective in reducing such disparities in achievement, particularly in mathematics (Gervasoni, 2001, 2002 & Darlington, 1983). Beginning intervention as early as possible is likely to be beneficial, and prevention is preferable so as to recover, and progression within the grade to avoid the difficulty of remediating failure embedded, future backlogs and gaps. (Brandt, 1993).

Furthermore, as I have indicated earlier poor performance worsens in Grade 6, which is the grade focus for this study. The standardised South African Annual National Assessment (ANA) for mathematics in

the Intermediate Phase (grades 4 – 6) also reveals that learner performance tends to decline progressively from the Intermediate to the Senior Phase (DBE, 2014). The same report on the 2012 to 2014 ANA results, reveals that in Eastern Cape Province Grade 6 learners achieved below 40% in mathematics. The DBE report (2014) additionally highlights that learners are not fluent in the foundational mathematics they will need for high school I note that this is the case in the Uitenhage District where the study was carried out (DBE, 2014).

Various reasons that could contribute to the challenges in mathematics education cited above have been mentioned in the previous chapter and have been suggested by many researchers. Spaull (2013) believes that poor mathematics results are also a consequence of learners' inability to read, write and compute. Similarly, Madihlaba (2013) emphasizes language as one of the reasons for poor performance in mathematics.

On the other hand, Maree, Aldous, Hattingh, et. al, (2006) argue that the "general poor quality of teachers and teaching" (p.229) is one of the key reasons for poor performance not only in mathematics but also in Science as well. Hence, Reddy (2006) argues that there is a need to continuously investigate possible solutions to the challenges encountered in mathematics.

Research indicates that language, quality of teaching and learning in mathematics, learners' lack of number sense and fluency in computation are not the only factors that impact poor performance and decline attainment grade by grade. Carnoy et al., (2012), Hoadley (2012), Spaull (2013), Reddy (2006) and Heyd-Mezuyanim and Graven (2015) list teacher knowledge, opportunities to learn, teaching time, home resources, and learner dispositions as contributing factors as well.

As mentioned in the previous chapter that in working with mathematics teachers in the Intermediate and Senior Phases (ISP) in my local district, they often complain that the CAPS' heavy content and assessment requirements lead to a lack of consolidation and practice, which in turns leads to the lack of opportunities to learn.

I also mentioned in the Introduction that many learners are pushed through (promoted) to the next grade with content gaps and backlogs in mathematics without any proper remediation or intervention in place to improve the situation. It is thus not surprising that there are weaknesses in mathematics performance and achievement among the majority of South African learners (Hebe, 2018).

In this context of poor and low performance by learners in mathematics due to the challenges cited above and the difficulties of improving this situation, I decided to try the Pushing for Progression (PfP)

Programme (from the SANC project) using the afterschool mathematics clubs as an intervention in my district with the aim of investigating if it would help to address such problems.

I provided a full synopsis about SANC project and its role in this study in the previous chapter. I have also included the role of club activities and games in mathematics teaching and learning. Now let me take you through to the theoretical framework underpinning this study.

2.3 Theoretical framework

In this section I detail the theoretical framework for the broader design of the mathematics clubs that inform the PfP Programme as an initiative to help address some of the challenges discussed above. Secondly, I present the socio-cultural perspective that frames this study. I then provide a review of literature that frames this study from a conceptual point of view.

2.3.1 Theoretical and conceptual underpinnings of the Pushing for Progression Programme

As the PfP Programme was used as an intervention for this study (the resulting clubs provide the empirical field), it is important to explore the theoretical and conceptual underpinnings of the Programme and the broader club design.

The afterschool clubs were conceptualised by Graven (2011) as an informal place where learning can take place in out-of-school time and were established as a new intervention initiative in the SANC Project in 2011 (Graven, 2016). Findings show that the clubs provide enabling spaces for both recovery and extension of mathematical proficiency in learners as they are free from several contextual constraints that teachers face in their classrooms such as large class sizes, curriculum and assessment constraints and so on (Stott & Graven, 2013). Additionally, the clubs should provide a safe space for trying new pedagogical approaches for the teachers and for the SANC project team as well as building confidence in these approaches (Graven, 2016). The model for the clubs has evolved over the last five years as reported in Stott (2016).

The PfP Programme evolved out of this earlier work and research. The Programme was designed by the SANC project (Stott & Graven, 2016) as one way of improving the quality of South African learners' achievement in primary school mathematics in response to various challenges identified by numerous researchers as previously discussed. According to Stott and Graven (2016), the PfP Programme is specifically aimed at developing number sense, flexibility and fluency in club learners. Additionally, the

club design as conceptualised by SANC project purposefully aims to develop both individual learner's mathematical proficiency and more participatory practices in a social club context (Stott, 2016).

The PfP Programme focuses on two of the five strands of mathematical proficiency offered by Kilpatrick et al. (2001), namely conceptual understanding and procedural fluency and more broadly on the development of number sense, learner progression and active participation. For the purpose of this research study I have concentrated on number sense and procedural fluency.

Theoretical assumptions underpinning this research

The Vygotskian (1978) view of social constructivism forms the theoretical basis of the PfP Programme and aligns well as the theoretical frame for this study as Vygotsky saw social and individual learning and development as dialectically linked. He 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).*

Vygotsky (1978) conceptualised development as the transformation of socially shared activities into internalised processes in his general genetic law of cultural development arguing that higher mental functioning appears first on the social level and then on the individual level.

> *Every function in the child's cultural development appears twice: first, on the social level, and later, on the individual level; first, between people ... and then inside the child… All the higher [mental] functions originate as actual relations between human individuals" (Vygotsky, 1978, p.57).*

Thus, from a social constructivist perspective, learning is an active process in which the social environment and context plays an important role. From this perspective, learning is mediated by other people who interact with the learner and use mediatory tools to facilitate the learning process. These tools are "psychological" (Vygotsky, 1978, p. 53) in nature, in that they are used to express thinking, and include language, signs, symbols, texts and mnemonic techniques.

The relationship between social and individual learning and development from a Vygotskian perspective forms the foundation for the design of the PfP Programme as the clubs aim to promote the development of individual learner mathematical proficiency and number sense; alongside more participatory mathematical practices. In other words, possible learning (in this case mathematical proficiency and number sense) could be realized socially by the club learners and facilitators in participating in a meaningful manner through collaborative ongoing engagements with the club community using the club activities in a fun, practical and engaging way.

Stott and Graven (2013) draw on Vygotsky's perspective on the role played by the social context in the cognitive development of the child and Sfard's (1998) acquisition and participation metaphors. The club design used Sfard's (1998) metaphorical mappings to theorise the theoretical basis of the PfP afterschool mathematics clubs programme as well. The metaphorical mappings reveal how the evolution in the learner's mathematical proficiency and number sense is a product of both the acquisition and the participation displayed in figure two below.

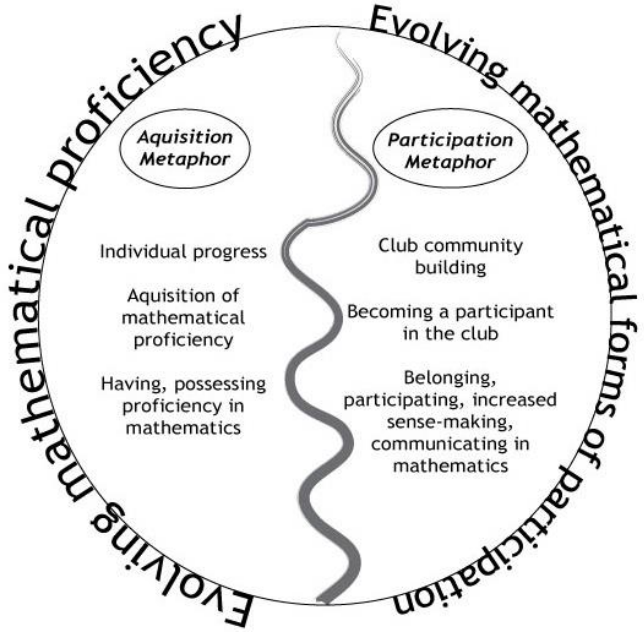


Figure 2: Theoretical mappings informing the design of the afterschool Clubs (Stott & Graven, 2013)

For mathematical proficiency and number sense to develop, the learners have to participate actively in mathematics club activities. Note that the two metaphors are said to be interdependent hence the line between the two is fine and blurred. It is through meaningful engagement with peers (other club learners)

and the teacher as the club facilitator (who all form the mathematics club community) that a sense of belonging develops in the learners. It is this sense of belonging that enable the learners to feel at ease and become more active in the mathematics club activities.

Stott and Graven (2013) argue the notion of working with both the acquisition and participation metaphors is not unique to the club space. However, learners participating in the PfP Programme intervention for this study were given the opportunity to acquire mathematical knowledge individually as well as through participation and working in collaboration with other learners in the clubs. In this way learners would be developing their mathematical proficiency by making sense of their mathematics as they engaged with club activities (Stott & Graven, 2013).

Next, I turn to the role of the club games, resources and activities used in the social context of the clubs that necessitate possible evolutions in mathematical proficiency (especially procedural fluency) and number sense as the focus of this study.

2.4 The role of club activities and games in mathematics teaching and learning

The PfP Programme afterschool club design is not only supported and grounded by the development of number sense and mathematical proficiency but also by the ethos and activities and resources promoted in the Clubs. Many of the club activities are game-based using playing dice and cards and are played collaboratively with peers and the club facilitator. The activities offered are designed to promote progression from using concrete methods to more efficient ones in a more actively, engaging and informal environment (South African Numeracy Chair, 2016).

Several authors have written about the importance and use of games to improve children's basic number skills and enhance their motivation during mathematics learning (Ainley, 1990; Barta & Schailling, 1998; Bragg, 2003; Cutler, Gilkerson, Parrott, & Bowne, 2003; Ernest, 1986; Gerdes, 2001; McConkey & McEvoy, 1986). For example, dice games have been used to develop children's counting skills and have produced significant improvement in enumeration and the construction of collections (Hughes, 1986; McConkey & McEvoy, 1986). Peters (1998) found that 5-year-olds who played math games in small groups supervised by parents made greater improvements in enumeration, knowledge of number sequence, and recognition of number patterns than children who did not play games.

Burns (2007) argues that learners who lack the foundations of mathematical understanding (such as number sense and procedural fluency in this case) on which to build might have multiple gaps and misconceptions that hamper their progress.

They have experienced failure and lack confidence, so such learners demand more time and attention that can be provided in a supplemental instruction that differs from the regular classroom. That is designed specifically to develop and recover the lack and gaps on such mathematical foundations. It is important to help learners make connections among mathematical ideas, so they do not see these ideas as disconnected facts (Burns, 2007, p. 16-17).

She suggests that, learners should be supported to recover gaps, build on new knowledge and make shifts in conducive and different environments than the normal classroom. For this study, this could be the afterschool mathematics club space where designed club activities, card and dice games are actively promoted. Burns suggests that games can be another effective way to stimulate learner practise (Burns, 2007).

Teaching mathematics through games is psychologically desirable since it stimulates learner motivation, active involvement, cooperative working and discussion with peers and facilitators. Oldifield (1991) supports Burns maintaining that games give enjoyment and provide a way of eliminating drudgery. He further proposes that games be used to attain the main objectives of teaching mathematics such as recovering lost content (i.e. filling gaps), gaining and developing of new concepts, practise and reinforcing skills. Finally, they are useful for developing number sense, procedural fluency and problem solving.

Biggs (1985), used games as a diagnostic tool and for teaching purposes. She found that learners attitudes changes, in that learners began to enjoy the work done and through such enjoyment, enthusiasm to engage and eagerness to accidentally learn through play grows, and so their conceptual understanding, problem solving skills and number sense deepened.

Griffin (2004) supports some of the significant gains offered by games. She maintains that games expose learners to various forms of number representations. She also found that while learners play games, they become motivated to play since they have a desire to win. Also, games have potential advantages over other means of instruction in that they are highly motivating, and they occur within a meaningful social context (Ainley, 1990; Bragg, 2003).

Furthermore, Venkat and Bowie (2017), also argue that since children enjoy playing games, well thought out games can be worthwhile tools to make a class fun while engaging the learners in mathematics.

Games can be incorporated in the mathematics class either as a fun starter to a lesson to provoke the children's curiosity… to capture learners' attention. The games can also be very useful for afterschool Mathematics clubs, … where teachers can enthuse learners and promote mathematical proficiency (fluency, reasoning and problem solving). Finally, share such games with other people to show the enjoyment in mathematics (Venkat & Bowie, 2017 p. 34).

I now turn to review the concepts that specifically underpin the research questions in this study.

2.5 Conceptual framework

My foundational frames for conceptualising and analysing are procedural fluency, number sense and progression trajectories. Kilpatrick et al.'s (2001) notion of mathematical proficiency includes procedural fluency which is one of five intertwined and interrelated strands. The other strands are conceptual understanding, strategic competence, adaptive reasoning and productive disposition. Although I agree that all five strands are crucial for mathematical proficiency, my focus in this study is on the relationship between procedural fluency and number sense for conceptualising and analysing learning in the clubs. Thus, in this discussion, I focus only on these two aspects and argue that learners need corresponding number sense to give meaning to the expanded notion of procedural fluency (fluency and flexibility).

Mathematical proficiency is described as "what it is to be successful in mathematics" (Kilpatrick et al., 2001). Being mathematically proficient means that a learner is numerate and understands the problem or task at hand. Additionally, learners can make connections to similar problems and can use models and multiple representations of such problem. Furthermore, the Intermediate Phase CAPS document (DoE, 2011) indicates that a mathematically proficient learner is able to calculate or compute accurately with confidence. S/he can use algorithms properly, apply what s/he has learnt, formulate and carry out a plan to solve a mathematical problem. Also, s/he can create similar problems, solve them using appropriate strategies. S/he can justify his or her responses logically, reflect and explain his or her own workings clearly. Finally, s/he can recognize when and how to engage. Sometimes, knowing how to tackle difficult tasks, persevere to get to the solution and share ideas.

2.5.1 Procedural fluency

Let me look specifically at the idea of procedural fluency now. Kilpatrick et al. (2001) define procedural fluency as the ability to solve a mathematical problem without referring to tables, calculators and other aids, using efficient ways to compute (add, subtract, multiply and divide mentally and on paper) and understanding when it is appropriate to use procedures or not. Meaning that, considering procedural fluency as the skill of carrying out procedures flexibly, accurately, efficiently and appropriately (Kilpatrick, 2001).

Kilpatrick et al. (2001) argue that procedural fluency is knowing how to solve a mathematical problem, and this include knowledge of step-by-step procedures, algorithms and rules for solving tasks. For example, in the domain of number, Kilpatrick et al. (2001) indicate that learners:

need to be flexible, efficient and accurate in performing basic computations with whole numbers (6 + 7, 17 – 9, 8 × 4, and so on) without always having to refer to tables or other aids. They also, need to know reasonably efficient and accurate ways to add, subtract, multiply and divide multi-digit numbers both mentally and in pencil and paper. As a result, such flexibility, accuracy and efficiency support the development of fluency in multi-digit computation" (p.11).

So, there is a link between flexibility and fluency. To me, if the learner is flexible in working with numbers, then the learner's fluency has been developed. Due to the fact that most of the data analysed and discussed in Chapters Four and Five displays more of flexibility than accuracy and efficiency, I will unpack *flexibility* and *fluency* as two aspects of procedural fluency.

Fluency

Kilpatrick et al. (2001) note that, procedural fluency includes the mastery or rapid recall and retrieval of basic facts and computational skills. Askew's (2012) "elements of fluency" (p.55) include basic facts and knowing basic methods such as adding or subtracting a single digit number to any number, adding a multiple of ten or 100 to any number, counting on or back in ones from any starting number, counting on or back in twos, tens, or fives from any starting number, multiplying any number by two or ten and multiplication facts up to 10 x 10 (2012). He argued that children are hampered if they are not fluent in knowing and using these basic facts and methods because "the point of being fluent in them is to free up working memory when tackling a more interesting and engaging piece of mathematics" (p.54).

Willingham (2009) supports this argument, indicating that automatic retrieval of basic facts is crucial to solving complex problems because "complex problems have simpler problems embedded in them" (p. 16). It is important that these facts can be retrieved quickly rather than being calculated, every time they are needed. Thus, fluency is about knowing the types of facts that Askew refers to. There is much debate about how these are taught (see Boaler, 2012 for example), but my focus here is on the importance of knowing these facts without referring to tables or using concrete methods such as fingers or tally marks to work them out. Since I believe that knowing such facts, will yield the accessibility, quick retrieval and ultimate flexibility envisaged here.

For instance, in the following example:

A learner who knows that 240×60 is also $24 \times 6 \times 100$ and that it is easier and quicker to access 24×6 than 240×60 since 24×6 *is* 20×6 *and* 4×6 or from simply using $20 \times 6 = 120$ and

$4 \times 6 = 24$ to get to 240×60 which is $144 \times 100 = 14\,400$ subsequently the solution for 240×60. Hence, the solver can retrieve known multiplication facts and make connections to get to the solution there will be no need to use error prone or inefficient strategies such as fingers and tallies, multiplication tables or a calculator.

Willingham (2009) also believes that children are fully capable of being fluent and making sense of foundational arithmetic procedures in order to be competent in their future mathematics. They will be at a better position to solve algebra, geometry, probability and be flexible enough to apply efficient strategies to problems confronted with in daily lives.

Flexibility

For Kilpatrick et al. (2001) the notion of flexibility in choosing an appropriate strategy for a given number range is an integral aspect of procedural fluency. They note that being flexible in using numbers increases number sense in learners. They also stress that learners need to be flexible in applying procedures as "not all computational situations are alike" (p.121) i.e. flexibility enables learners to select an appropriate tool or approach for a given situation and number range.

For example, a flexible learner may work out 23 plus 18 mentally using doubles, number bonds and then group the numbers according to number and place values. Starting by recognising that within 23 there is also 18 as follows:

$$\begin{aligned} &18 + 18 + 5 \\ &= 36 + 4 + 1 \\ &= 40 + 1 \\ &= 41 \end{aligned}$$

Another flexible and efficient way would be decomposing 18 into 7 and 11 so that 7 can be bonded with 23. Then add the rest according to place value as in the following example:

$$\begin{aligned} &23 + 7 + 11 \\ &= 30 + 10 + 1 \\ &= 40 + 1 \\ &= 41 \end{aligned}$$

Star (2005) supports Kilpatrick et al.'s argument. He claims that deep procedural knowledge involves "comprehension, critical judgement" (p. 408) and includes flexibility. He maintains that flexibility is a nontrivial and overlooked competency and argues that it is not sufficiently explained in definitions. He also highlights that many people say that flexibility can be observed when someone uses the most efficient strategy to solve a problem. Yet, he asks, what is the most efficient strategy? Is it the quickest and easiest to do; the one with the fewest steps? The one done mentally, the one that someone likes the best or the one that make sense to solver? Some answers to these questions may arise in the data collected for this study.

Additionally, Star (2005) believes that judgement or decisions on which approach to use will be based on the solver's level of procedural knowledge. Star argues that someone with superficial procedural knowledge will have no choice but to use a standard strategy. On the other hand, someone with more flexibility and deeper knowledge of procedures, will have more choices. These are important considerations for me as flexibility is a key way for analysing shifts in learners' methods.

Burns (2007) claims that many mathematics educators note that children do not know how to work with more flexible methods or different strategies. They need to be exposed to and be encouraged to use a variety of strategies for solving mathematical problems so that they learn when to apply different strategies for different problem- solving scenarios.

Burns (2007) maintains that if learners think or were taught that there is only one correct way to work out something, they will focus on learning how to apply that single method, rather than thinking about what makes sense for the numbers they are to work with (compute) or which strategy or method is more efficient and accurate. Meaning that the skills that encourage number sense, flexibility, efficiency and accuracy as aspects of procedural fluency need to or rather should be developed and taught to learners.

Let me now take you to the notion of number sense and procedural fluency, but firstly let me define what number sense is as this another concept that frames this study.

2.5.2 Number sense

Klein and Starkey (1988) found that we are born with a sense of number. They measured the focus time of babies looking at pictures of dots and discovered that when the number dots changed, the babies' length of time spent looking at the pictures of dots changed too. They note that the babies have appreciated a difference in numerical quantity. Also, young children can recognize the number of items

in a group without having to count them. This is called subitizing, and most people can subitise up to six to seven items when they are randomly arranged.

Other mathematics educators and researchers such as Anghileri (2006) state that number sense is the ability to work flexibly with numbers, observe patterns and relationships and make connections to what they already know, as well as to make generalisations about patterns and processes.

Burns (2007) supports this and maintains that learners with a strong number sense are able to "think and reason flexibly with numbers, use numbers to solve problems, spot unreasonable answers, understand how numbers can be taken apart and put together in different ways, see connections among operations, figure mentally, and make reasonable estimates" (p. 24).

Hornigold (2017) further states that number sense is an emerging construct that refers to the learner's fluidity and flexibility with numbers; what numbers mean as well as an ability to perform mental mathematics to look at the world and make comparisons. Hornigold emphasizes that number sense develops gradually over time and at different rates for different children, through exploring numbers, visualizing them in a variety of contexts, and relating them in ways that are not limited by formal written methods.

Thus, to me the ability to work flexibly with numbers, understanding how the number system works and how the numbers relate to each other is making sense of numbers. I also believe that learners with good number sense have a range of mathematical strategies at their disposal, they know how to adapt them to meet different situations and thus display fluency and flexibility.

2.5.3 Linking procedural fluency and number sense

I argue that learners need corresponding number sense to give meaning to the flexible types of choices that Star, Askew and Willingham speak of. Returning to the notion of number sense referred to earlier, if a learner can work flexibly with numbers, observe patterns and relationships, make connections to what they already know and make generalisations about patterns and processes, they will have more choice as to the strategy to use to solve a problem; they will have increased flexibility. Thus, learners have several approaches to compute and solve problems and can use and adapt these for new situations. For example:

A learner who has developed number sense and flexibility in multiplication may use known facts and estimation to solve 29 x 19, by recognising that there is no need to use an algorithm as this set of numbers

could be solved mentally by using either a compensation or estimation as a strategy. The learner may start by using known facts to multiply by a decade number to estimate the answer is approximately 30 x 20 = 600. Perhaps drawing on knowledge of doubles and multiplying by 10, the learner may know that 29 x 20 = 580. The learner may then compensate for the extra 29 and subtract it from 580 (580 – 29 = 551) to arrive at an answer. Thus, the learner makes sense of the numbers in the problem and has a range of approaches to select from, using them flexibly. Procedural fluency (including fluency and flexibility) is shown in knowing the multiplication facts and in the flexibility of choices.

The South African Foundation Phase curriculum document (DBE, 2011b) indicates that learners need to "exit the Foundation Phase with a secure number of sense and operational fluency" (p. 8). The document states that number sense includes understanding the meaning of and relationship between different kinds of numbers; the relative size of different numbers; being able to represent numbers in various ways and the effect of operating with numbers. I note similarities between elements of number sense and procedural fluency such as being able to work flexibly with numbers, work things out mentally as well as knowing when and which facts to apply.

The club learners in this study were in Grade 6 and by this grade, learners are expected that learners should have access to a range of strategies for solving problems in the four basic operations. The Intermediate Phase CAPS document (DBE, 2011a), indicates that Grade 6 learners develop more efficient techniques for calculations based on a foundation of place value and understanding of the properties of numbers and operations before they do so.

The IP CAPS document highlights that learners should be able to add and subtract whole numbers to at least 6 digits, multiply to least whole 4-digit by 3-digit numbers and divide to at least whole 4-digit by 3-digit numbers. Additionally, learners should use "a range of techniques to perform and check written and mental calculations of whole numbers" (p. 14) including: estimation, column algorithms, building up and breaking down numbers, rounding off and compensating, using addition / subtraction and multiplication / division as inverse operations.

As indicated earlier in this chapter, research in South Africa shows that this is not the case. Many Grade 6 learners are stuck using concrete methods such as tally marks to answer problems (Schollar, 2008). Research shows that Grade 6 learners will generally try to solve problems using an algorithm (a standard technique they are taught at school). If this approach fails, they tend to fall back on using their fingers or tally marks. Star (2005) explains that this scenario can occur when procedural knowledge is superficial;

learners will have no option but to use a standard technique to solve a problem. Learners with deeper knowledge will have more choice in the range of strategies they can choose from and use.

2.5.4 Progression trajectories

I turn now to look at literature connected with learner progression as this is another way to think about shifts in learners' mathematical proficiency. Additionally, progression spectra are provided to teachers as part of the PfP Programme. Thus, the teachers who participated in this study were exposed to these spectra through the workshops.

Graven and Stott (2012) argued that while the Kilpatrick et al.'s (2001) notion of mathematical proficiency is a powerful conceptualisation, it is difficult to evaluate learner progress using the five strands as their intertwined nature means they are all required to be present. They argued that to assess learner numeracy progression over time, the fully idealised versions of each strand need to be unpacked to identify varying levels of learner progression and that it is important to assess the extent to which a learner may or may not have mastered a particular aspect of mathematics at different points in time. Learning progression trajectories are one way of unpacking the extent to which learners are mastering procedural fluency and number senses development in that they describe the broad learning path that learners typically follow.

The work of Wright, Stafford, Stanger and Martland (2006) on defining levels of mathematical progress in their early Learning Framework in Number (LFIN) is one useful way of unpacking learning trajectories. Their Mathematics Recovery (MR) Programme includes the Learning Framework in Number (LFIN) and a one-on-one learner interview assessment tool. This assessment tool enables teachers to profile where learners are on the LFIN and to understand the developmental nature of numeracy learning. Here I see the interconnection nature of assessment and learner profiling along a learning trajectory.

More recently Graven and Stott (2012) developed visual procedural fluency spectra for various assessment tasks for analysis of learner methods / responses. Research emanating from the SANC project has shown that many progression models are too complex and time consuming for teachers in South African schools (see Stott, Mofu & Ndongeni, 2017 for example). Thus, in the PfP Programme (the intervention used in this research), the teachers were provided with two spectra for the four basic operations of addition, subtraction, multiplication and division that described a learning trajectory for the club learners. These two spectra have a specific focus on unpacking and understanding number sense and procedural fluency.

These spectra draw on the ideas from many learning trajectories, such as Wright et al. (2006) and Graven and Stott's earlier work with the procedural fluency spectrum (see Stott, 2017). The design of the spectra includes elements of number sense and procedural fluency discussed in this review and both are evident in the descriptors for the methods along the continuum.

For example, in Grade R, learners learn to count concretely by using objects, fingers, drawings and so on. As learners' progress through Grade 1, 2 and 3 and into the Intermediate Phases, I would expect them to progress further towards more flexible, fluent methods as they develop their number sense and procedural fluency. Thus, as learners get older, we expect them not to use fingers, tally marks and drawings to solve problems as these would now be considered as constrained methods. It is important to note that the constrained and less constrained methods will work very efficiently for smaller numbers (in the range 0 to 20) but will become increasingly cumbersome when the number range gets bigger, especially in multiplication and division. As mentioned previously, many South African learners are still stuck using these constrained methods, even in the Intermediate Phase grades.

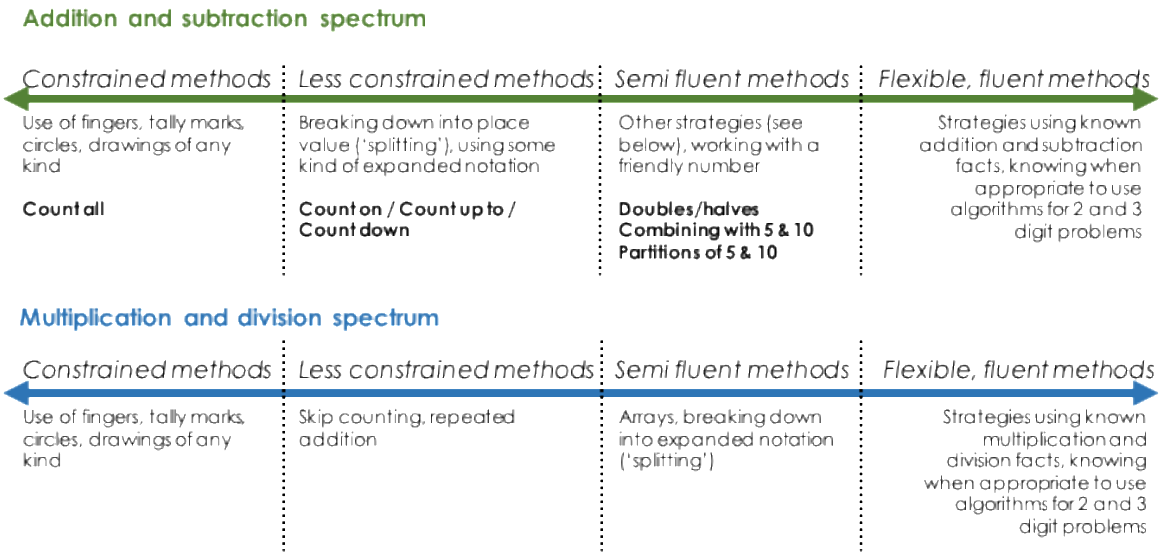


Figure 3: Addition/subtraction and multiplication/division spectra taken from the Pushing for Progression Programme

2.6 Concluding comments

In this chapter I have discussed the theoretical and conceptual underpinnings of the PfP Programme and those of this study. I have reviewed the literature relevant to the conceptual notions that I use for addressing the research questions and to analyse the data. In the next chapter I provide the Methodology

used for this study. This also includes more detail about the about the activities promoted in the match Clubs during the 15-week PfP Programme.

In the next chapter I deliberate on the research design and methodology used in this study.

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

I anchor this chapter with the main goal of this research and the research questions. I then provide details of methodological orientation and framework employed in this research; including the research design, study, field and the position of the researcher. Then, I discuss the nature of methods used to collect data, instruments, data source, research timeline and analysis of such data. Finally, I deliberate on ethical considerations.

The main goal of this research was to investigate if the clubs could be a productive learning space for learners when run by teachers. Therefore, this research aimed to explore two main aspects: the nature of learners' changing mathematical proficiency (specifically procedural fluency) and number sense, as a result of participation in after school clubs and how these might evolve through club participation; and teachers' experiences of working with learners in a club space.

The unit of analysis in this study was therefore both the learners' changing mathematical proficiency in the clubs and the teacher facilitators' experiences of working with learners in the club space. In pursuit of my research goal the following research questions have been asked: -

1. What changes were evident in learners' mathematically proficiency and number sense through club participation?
2. What were teachers' experiences of learners' changing mathematical proficiency and number sense as a result of participating in the clubs?
3. What were teachers' experiences of working with learners in the club space?

3.2 Overview of methodological orientation and framework

This study works within an interpretive paradigm. An interpretive paradigm is based on a concern for the individual, in this case, the learners participating in the clubs. Essentially, the aim of interpretive research is to understand the subjective world of human experience, to understand and interpret the world in terms of the people who participate in that world (Cohen, Manion & Morrison, 2000).

This research is a multi-site case study using five afterschool mathematics clubs. Yin (2009) states that a case study approach is an approach to qualitative research that "investigates a contemporary phenomenon in depth and within its real-life context". Denscombe (2010) characterises case study

research as emphasizing a number of different aspects including depth of study rather than breadth of study, the particular / specific rather the general, natural settings rather than artificial situation and the use of more than one research method.

A number of these characteristics are important for my study. The case study approach allowed me to investigate the phenomenon of shifts in learner's mathematically proficiency in depth while they participated in after school clubs and portray, analyse and interpret the complexity and uniqueness of these real learners and the situation within the real-life context of the clubs. Additionally, I was able to explore learners in five specific clubs which are operating in this real-life, learning context. The clubs were not set up for research purposes – they were set up as a real intervention for poor performing learners.

Yin (2009) states that the same study may contain more than one single case. As I used five clubs, my design used is what he calls the multiple-case design variant. Bishop (2010) 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 synthesis (p.589).

The research design in a multi-site case study is the same across all sites and all sites are studied sing the same key research questions, with the same data collection, analysis and reporting approaches. This is the case for the design of the five clubs in this study. Yin (2009) states that analytic conclusions arising from two or more cases "will be more powerful than those coming from one single case" (p.61). The logic followed in selecting multiple cases is replication of results and not sampling (Yin, 2009). That is, multiple cases make stronger claims possible by replicating emerging patterns among the different cases studied. This has been useful for the analysis of the data in this study.

Subsequently, the multi-site case study design may also increase to some extent, broader applicability of the findings and enable the use of the comparisons to support my conclusions, thus strengthening the case for external validity (Stott, 2014).

3.3 Research field and sampling

The Uitenhage District is one of 23 districts of the Eastern Cape Province in South Africa. Kwa Nobuhle, Kwa Langa and Rosedale are previously disadvantaged townships of the semi-rural Uitenhage district. These three townships comprise of two racial groups mainly Black and Coloured.

The 5 sampled schools are among the 128 primary schools of the Uitenhage District. These were chosen because all club sites in Kwa Nobuhle are less than a kilometre apart which made it easier for me to access them. The same applied to the other two sites as they were not far from each other and my work place is central to all of them. The five after school mathematics Clubs are situated in these five schools (sites).

The medium of instruction[1] in four of the schools is English, three of them are in KwaNobuhle and the other one in Kwa Langa townships. There is only one school in Rosedale and whose medium is Afrikaans. I wished to maximize diversity as much as possible and for the schools to be "as like the population of interest as possible" (Firestone, 1993).

According to Cohen et al. (2000), my case is a 'non-probability sample' as I targeted a particular set of schools with full knowledge that they do not represent the wider population of schools in my district; they rather represent themselves. Moreover, my case is of the 'convenience' sampling type which is known as accidental or opportunity sampling which involves choosing the nearest individuals to serve as respondents (Denscombe, 2010).

Nine teachers were selected to participate in the study. Five of these teachers who facilitated the clubs are enthusiastic lead teachers, who were elected by other teachers in their cluster to participate in the study due to their experience and expertise in mathematics. Also, they have shown interest in running the clubs. They were supported by the other four teachers from their respective schools.

Each of the five grade 6 teachers ran clubs in their respective schools with 12 learners. This resulted in a total sample of 60 learners with respect to learner data collection. The learners were selected by the teachers themselves from the pool of low attaining learners in their classes, who showed interest in participating in the clubs. Low attaining learners are those learners that perform below 50% with the achievement Levels between 1 and 3 according to the scale of achievement of National Curriculum Statements, Grades R – 12 in mathematics (DBE, 2011[2]).

[1] Medium of instruction: Language of Learning and Teaching (LoLT), mathematics in grade 6 is taught in the LoLT of that particular school.

[2] National Policy Pertaining to the Programme and Promotion Requirements (NPPPR) of the National Curriculum Statements (NCS) in Grades R to 12.

3.4 Positioning myself as the researcher

While conducting the study I was aware that my role as both a district official and researcher makes my position complex. In this section I would like to clarify the nature of these roles. Figure 4 below summarises the relationships between me as the researcher and other parties involved in the PfP Programme and research study.

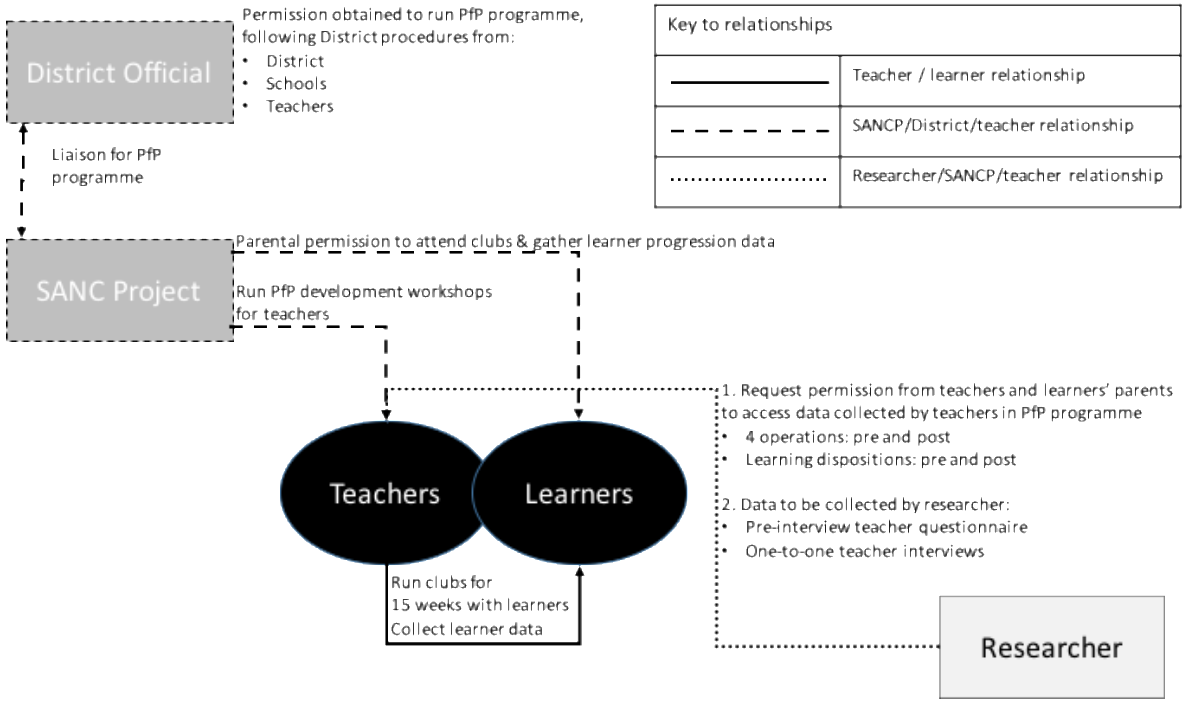


Figure 4: Summary of my relationships as a researcher

My role as district official

I am currently a Senior Education Specialist (SES) and curriculum/subject advisor for mathematics in the General Education and Training (GET) band for the Intermediate and Senior Phases (ISP) under the Curriculum Management and Support directorate. I have been careful to draw up research questions that do not involve me measuring the impact or effectiveness of the PfP Programme on teacher practice in the schools that I work in. Rather I investigated whether the Clubs were a productive space for learners (and teachers) when run by teachers rather than the SANC project team members. The relationship between my work responsibilities and my research is thus different. It was my intention that my current position would support rather than negatively affect my research or the teachers. As I discuss below, this

distinction was made clear to the teachers both in writing and verbally prior to their participation in the clubs and before one-to-one interviews were conducted.

Relationship with teachers and learners

I was aware of the possible power relations between myself and the teachers who had facilitated the clubs and how this might influence the research process, their participation in it and the results. I endeavoured to establish a partnership with facilitators. I have been a teacher and a colleague to them through all my teaching 12 years at Limekhaya high school in Kwa Langa township of Uitenhage. I also work closely with them as they are cluster leaders in our district. My relationship to them is based more on collegiality than authority. I have a long healthy working relationship with them within the 11 years as a subject advisor and strive to maintain it as such. Furthermore, I worded my research questions so as not to investigate teacher learning and impact of their classroom practice. Rather they seek to understand their experiences of working in the club space. In this way the relationship with the teachers was carefully managed to promote a situation of mutual benefit and collaboration and not one of authority.

For the purposes of this research, I had no direct contact with the learners in the clubs. All the data on pre- and post- assessments scripts was collected by the teachers in the club space. I requested permission from the Eastern Cape Provincial Department of Education (ECPDE) research directorate; my immediate work supervisors, District Deputy Chief Education Specialist (DCES) and Chief Education Specialist (CES) of Curriculum management and support; the school principals; the teachers and learners' parents to access this data for the purposes of my research.

Relationship with South African Numeracy Chair (SANC) Project

I have a dual relationship with the SANC project. The first is as a district official where I have been responsible for liaison with the SANC project team in setting up the PfP Programme in my district as I believed that the Programme would be beneficial for both teachers and learners. My part in this Programme with this set of teachers is now complete as this initiative has already taken place. No doubt I will continue to maintain this relationship with the SANC project after my research is complete.

My second relationship is with my supervisors, one of whom was the facilitator of the PfP Programme for this study. As part of the PfP Programme, parental permission for learners to participate in the Programme and for collecting the learner data for monitoring the Programme from the participating teachers was obtained. The SANC project has used and analysed the data to combine with other similar

data from other PfP Programmes in South Africa to gauge the possible impact of clubs on learner progress.

3.5 Research timeline

In the following table I provide a synopsis of how this research study unfolded:

Table 1: Research timeline

Date	Type of event	Description	Which research question addressed	Data Collected	Number of each collected	Analysis approach used
April 2016	1st club 4 operations pre-assessment	Administration of learner 4 operations pre-assessment Playing Beetle & Make 12 game	Sub-question 1: What changes were evident in learners' MP and NS through club participation.	Individual learner scripts	60 learners' scripts	Scores & learner method analysis
June, July & Aug. 2016	PfP Programme Teacher development workshops	Professional development of teachers on how to develop Fluency, Flexibility and Number sense: (using of number line and grid method)				
Sept. 2016	4 operations post-assessment	Four operations of post-assessment	Sub-question 1: What changes were evident in learners' MP and NS through club participation.	Individual learner script	60 learners' scripts	Scores & learner method analysis
Sept. 2016	Proposal approval					
Oct. 2016	Request permission to undertake research from the EC. DoE.					
Nov. 2016 – Jan. 2017	Gained permission from teachers and learners' parents to access the collected data from the PfP Programme Research permission from district, schools and teachers					
Jan. 2017	Approval of permission to undertake research					
Jan – Mar. 2017	Administer the post-club teacher questionnaires to the teachers					
Feb – Mar. 2017	Analysis of teacher-gathered PfP data					
Apr – Aug. 2017	Transcribe and analyse the first teacher questionnaires					
Sept – Nov. 2017	Conduct five one-to-one teacher interviews	8 teachers interviewed	Sub-question 2: What were teachers' experiences of learners' changing MP and NS as a result of participating in the Clubs?	Audio recordings	6 teachers' recordings	Interview transcripts & thematic analysis
Jan. – Mar. 2018	Second round of interviews	8 teachers interviewed	Sub-question 1 – 3: What were teachers' experiences of working with learners in the club space?	Audio recordings	6 teachers' recordings	Interview transcripts & thematic analysis
April, May, June 2018	Analysis, interpretation and discussion of data with teachers					
July – Nov. 2018	Write up of research report					
Jan. 2019	Submission of final version of thesis					

3.6 Description of the intervention

As indicated, the PfP Programme runs over a 15-week period. Workshop One orientated the teachers to the key ideas of the Programme, introduced the spectra and assessments, as well as allowed the teachers to experience the activities required for the first three clubs. Workshop Two focussed purely on addition and subtraction and covered the concepts and activities required for the next 6 sessions (session 4 to 9). Workshop Three focussed on multiplication and division and covered the concepts and activities required for the last 6 sessions (session 10 to 15).

In the club sessions, teachers were encouraged to do on-going informal assessment and profiling of learner progress. In the 15th session teachers re-administered the same assessment as post assessment and re-profiled learners. Table 2 below provides details of the programme that was the intervention for this study. Note: w/c in the table below indicates week commencing dates.

Table 2: PfP Programme timetable for the intervention this study is based on

Weekly timetable	Week 0	Weeks 1 to 3	Week 3	Weeks 4 to 9	Week 9	Weeks 10 to 15
Event(s)	Workshop One	Run 3 weekly club sessions	Workshop Two	Run 6 weekly club sessions	Workshop Three	Run 6 weekly club sessions
Dates	12th April (12:00 – 16:00)	w/c 18th April w/c 25th April w/c 2nd May	13th June (12:00 – 16:00)	w/c 9th May w/c 16th May w/c 23rd May w/c 30th May w/c 6th June w/c 13th June	13th June (12:00 – 16:00)	w/c 21st June w/c 18th July w/c 25th July w/c 1st August w/c 8th August w/c 18th September

Teachers who participated in the PfP Programme were provided with three handbooks, one for each workshop. The handbooks provided teachers with detailed guidance on what to do for each club session in terms of preparation, resources needed, how to group learners and detailed descriptions of the activities. A sample club session is provided in Appendix 4.

Although this was not intended, I ran an adapted version of the standard PfP Programme "on demand" as the teachers requested other workshops to help them understand the different computing strategies for the four operations that they are not comfortable with and the concepts of fluency and number sense.

Prior to undertaking this study, I visited the club sites. This was as a way of supporting the teachers (club facilitators) and to observe the clubs for my own learning and to get a sense of how they were being run.

Club facilitators would share their experiences during my visits. Those experiences were noted to report progress to the SANC project team, school principals and authorities at work. Following the first two club sessions (at end May 2016), we had a learner pre-assessment results profiling meeting. At this meeting the club facilitators were given a platform to share their experience of running the first two club sessions. They reported that they were struggling with some of the procedures and activities used in the clubs. They requested further workshops on areas of need. We thus had three extra workshops on the use of the number-line on the four operations, the array (grid) method for multiplication, compensation in addition, use of doubling, halving, multiplication and addition facts in all operations. These concepts were done to support the development of fluency and number sense as well.

The facilitators themselves also made "on the ground" adaptions to the Programme whilst running the clubs. For example, one of the club facilitators, club Facilitator C1 explained that she realised the club sessions took too long for the learners to understand her explanation of activities and the club session was not long enough. She decided to introduce club buddies. Club buddies were learners that were selected from a pool of what she terms as 'bright sparks' (those that attain level five to seven in mathematics) from her three grade six classes. The role of the club buddies was to explain to the club members and work with them but not for them during the club sessions.

Club Facilitator C1would sit for an hour in the morning (6:50 to 7:50) of the club session day with the buddies and run through the activities of the club. Then, afterschool they were joined by the club members. Each club member was paired with a club buddy who sat next to him or her and explained the club proceedings. She claimed that this practise was beneficial to the club learners and formed strong bonds amongst her learners. There was adequate time in the club sessions, and she could finish all the activities planned for that day. Thus, she had 24 club members rather than twelve as in the initial club design.

We (the club facilitators and I) had a WhatsApp group as a platform where club facilitators were able to share their experiences of the club sessions. Club Facilitator C1 shared the concept of club buddies she had introduced. Another facilitator from site E liked the idea and introduced it to his site. After exploring the idea, Club Facilitator E1 shared the same sentiments as Club Facilitator C1.

Club sites A and D also experienced the same delay pertaining introducing activities to learners and the club facilitators decided to extend the club session by an hour. Only club site B did not augment the initial afterschool mathematics club Programme with additional or adapted sessions.

3.7 Data collection methods

I used both *qualitative* and *quantitative* methods of data collection for this study. Therefore, this is a mixed method study. A mixed method study is characterised by research questions or data collection methods that draw "inferences using both qualitative and quantitative approaches or methods in a single study" (Tashakkori & Cresswell, 2007 p.4). Ross and Onwuegbuzie (2012) cite five purposes for integrating quantitative and qualitative approaches in a mixed method approach, namely:

- Triangulation: comparing results from quantitative data with qualitative findings to assess levels of convergence;
- Complementarity: seeking elaboration, illustration, enhancement, and clarification of the findings from one method with results from the other method;
- Initiation: identifying paradox and contradiction stemming from the quantitative and qualitative findings;
- Development: using the findings from one method to help inform the other method; and
- Expansion: expanding the breadth and range of a study by using multiple methods for different study phases (p. 89).

A mixed methods approach provided a means of *triangulating* data collected by the participating teachers from the PfP Programme, as well *as initiation and development* where the results from one method highlighted cases of interest to generate questions for another method, as in the four operations data and post club teacher questionnaires informing the subsequent one-to-one teacher interviews.

As mentioned previously, some data was collected exclusively for this research study (e.g. teacher questionnaires and interviews), while other data was collected by the participating teachers. This data was collated by the SANC project team as part of monitoring the effects of their broader PfP development Programme. As part of my study I requested permission from the teachers to access and draw on the data already collected for use in this study. The different methods used in this study are shown in Figure 5 below and I will indicate the type of data generated as I discuss each data collection method in the section that follows.

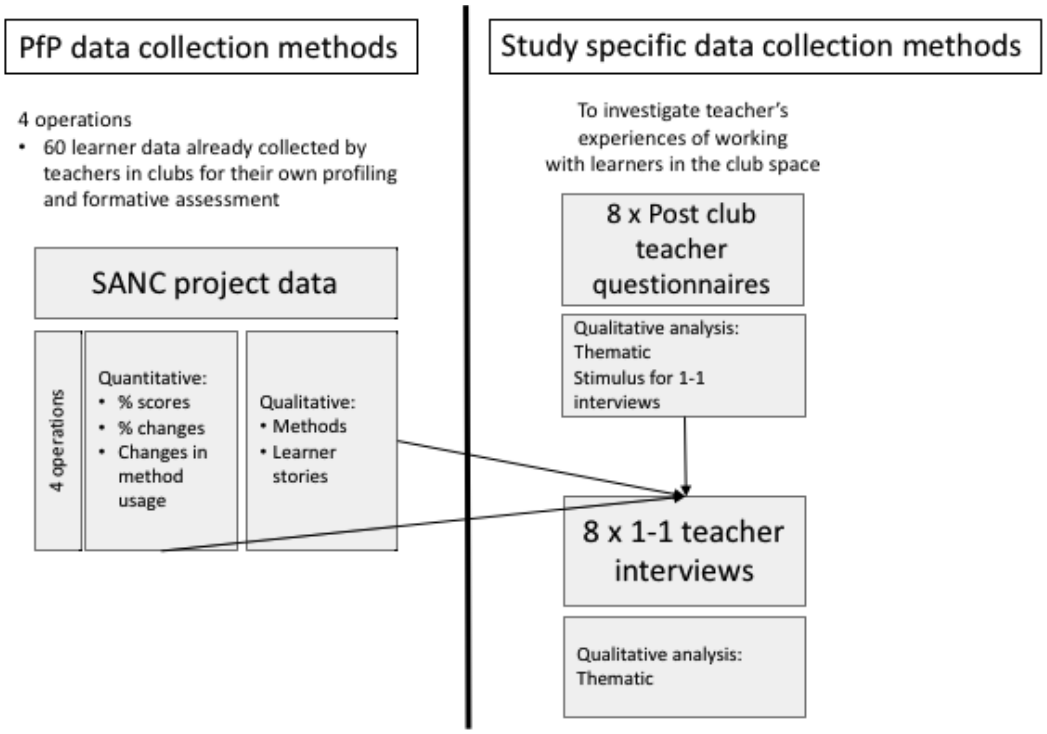


Figure 5: Summary of data collection methods for this study

PfP Programme data collection instruments: Four operations assessment

This data was collected by the participating teachers. I used it to address research question one. Permission was sought from participating teachers and learners' parents to draw on this data. The data was accessed from each individual teacher who ran a club as part of the PfP Programme.

The PfP uses an instrument with 5 items for each operation ranging from 1-digit to 3 by 2-digits (see Appendix 1) for the full instrument. This is used to assess learner progression in mathematical proficiency. In the first club session learners completed the assessment before they began to participate in club activities. The assessments and an assessment schedule (see Appendix 2) were used by the teachers to profile each learner according to a progression spectrum shown below (Figure 3) and to guide individual learning experiences for the club participants. The same instrument was used after 15 weeks of learner participation in clubs as a post-assessment to determine whether individual learners progressed.

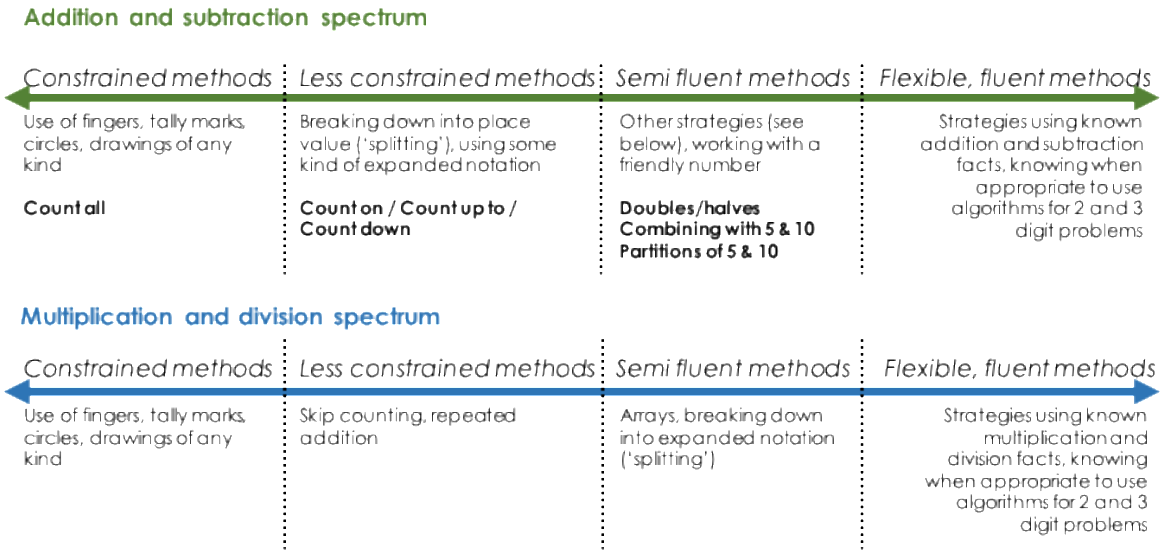


Figure 6: Addition/subtraction and multiplication/division spectra for the PfP Programme

Learner scores on both the pre- and post- assessment as well as the percentage point change provided quantitative data for this study. Individual learner cases were also noted for discussion in the teacher one-to-one interviews. In this way this data informed the questions asked in the interviews using what Ross and Onwuegbuzie (2012) call the development feature.

Post-club teacher questionnaires

I hand delivered these questionnaires to teachers late in January 2017. I then secured appointments with teachers for February and March for the one-to-one interviews. The aim of the questionnaire was to

enable the teachers to reflect on their experiences of working with learners in the club space as this space and practices were intentionally different to their daily classroom environment and routine, thus interrogating some of the more social aspects of the clubs. This data was used to address research question three and to inform the questions I asked in the teacher one-to-one interviews. See Appendix 5 for the teacher questionnaires.

Teacher one-to-one interviews

These interviews qualitatively investigated *all* the research questions with the aim of collecting deep, rich data. Previous analysis of learner data and question described above was used as a stimulus to inform the questions asked for the teacher interviews as shown in Figure 2 above. The interviews allowed me to ask the teachers to elaborate and give more details of learner progression and their own experiences of working in the clubs.

One–to–one semi structured interviews were conducted with the five grade 6 teachers and the other two support teachers who facilitated the Clubs. I audio recorded all interviews and used my journal to take notes on teacher learning experiences in facilitating the Clubs. Since "interviewing people is a natural way of interacting with people than making them fill out questionnaires or do a test" (Kelly, 2006 p.297). A semi-structured interview schedule was designed before the interviews were conducted using the analysis of the SANC project four operations data and the pre-interview teacher questionnaires. The interview questions on the interview schedule addressed all the research questions developed for this study.

3.8 Data transcription and data entry

I undertook the transcription of the questionnaires and one-to-one interviews myself (see Appendix 6). To ensure that my ethics protocols protected the rights of the participants I assigned acronyms as pseudo codes to all. For example, for the first club facilitator of club site A, the participant's code is CFA1. The learners' pre- and post-assessments scripts were also scanned into a digital copy so as to provide evidence of methods learners used to answer assessment items.

Table 3: Club, teacher and learner pseudonyms

Club Pseudonym	Teacher (Club Facilitator) Code	Club Learner Codes
A	CFA1 and CFA2	A1 to A12
B	CFB1 and CFB2	B13 to B24
C	CFC1 and CFC2	C25 to C36
D	CFD1 and CFD2	D37 to D42
E	CFE1	E42 to E60

Data entry and creation of 4-operations scores, changes and averages

I have drawn on methods used by SANC project team over the last five years (Stott, 2014), to calculate scores and percentage changes for this data.

Each learner's script was reviewed by the participating teacher facilitator and a score given out of 20. The scripts were then copied and given to me. For analysis purposes, I entered this data into a spreadsheet to enable change data, averages and graphs to be created, for both the pre-assessment and the post assessment. For each learner, individual items on the assessment were allocated a binary indicator: 1 for a correct answer and 0 for an incorrect answer. The items were also grouped according to their relevant operation (purple, green, blue and turquoise as shown in Figure 6 and Figure 7) and scores worked out for each operation out of 5 to enable later analysis of progression in the different operations.

Individual learner data was grouped together for a particular club, enabling club averages to be worked out. Similarly, all learner data was grouped together to enable overall PfP Programme averages and changes to be calculated. A sample extract of the data is shown below for a sample learner.

PRE-TEST

Script Number	Pre-test date	Name	Club name	Grade	Addition Pre	1.1 Pre	1.2 Pre	1.3 Pre	1.4 Pre	1.5 Pre	Subtraction Pre	2.1 Pre	2.2 Pre	2.3 Pre	2.4 Pre	2.5 Pre	Multiplication Pre	3.1 Pre	3.2 Pre	3.3 Pre	3.4 Pre	3.5 Pre	Division Pre	4.1 Pre	4.2 Pre	4.3 Pre	4.4 Pre	4.5 Pre	Pre score	Total Pre
A1	2016-04-19	A1	Club A	6	0.4	1	1	0	0	0	0.0	0	0	0	0	0	0.0	0	0	0	0	0	0.0	0	0	0	0	0	2	0.1

POST-TEST

Script Number	Name	Club name	Grade	Post-test date	Addition Post	1.1 Post	1.2 Post	1.3 Post	1.4 Post	1.5 Post	Subtraction Post	2.1 Post	2.2 Post	2.3 Post	2.4 Post	2.5 Post	Multiplication Post	3.1 Post	3.2 Post	3.3 Post	3.4 Post	3.5 Post	Division Post	4.1 Post	4.2 Post	4.3 Post	4.4 Post	4.5 Post	Post score	Total Post
A1	A1	Club A	6	2016-09-27	0.6	1	1	1	0	0	1.0	1	1	1	1	1	0.8	1	1	1	1	0	1.0	1	1	1	1	1	17	0.85

Figure 6: Example of pre and post-test data entry on spreadsheet for one learner (A1)

CHANGE DATA								
Script Number	Name	Club name	Grade	% point Chg Addition	% point Chg Subtraction	% point Chg Multiplication	% point Chg Division	Overal % point Chg
A1	A1	Club A	6	20%	100%	80%	100%	75%

Figure 7: Example of calculated change data on spreadsheet for one learner (A1)

4-operations learner method data

There are 240 responses per club per assessment item (12 club learners x 20 items = 240). The learners' pre and post-assessment scripts were examined for their methods. The data was once again entered onto a spreadsheet for each club and learner. Both correct and incorrect answers were examined, and the number of responses were counted for: *no shown workings* (coded as NSW), *non-tally method* workings (NT) such as traditional algorithms, doubling, halving, decomposition of numbers into place values and *tally* methods. Responses between the pre- and post-assessments were compared to calculate the change in number of responses used by club learners. A sample data entry spread sheet is shown in Figure 8 and Figure 9 below.

Summary of learner methods in the 4 operations pre assessment

School/club code: Club A — Number of learners: 12

Problem	Frequency of…							Totals			
	Correct answers without written working	Correct answers with written NON-TALLY working	Correct answer using TALLIES	Wrong answer without written working	Wrong answer with written workings	Wrong answer using TALLIES	Not answered	Number of correct answers	Number of wrong answers	Number of answer using tallies	Check column (no. of responses must equal number of learners)
Addition											
3+4	7	3			2			10	2	0	12
8+6	7	3			2			10	2	0	12
23+18	3	3		3	3			6	6	0	12
55+67	2	3		3	4			5	7	0	12
104+97		1		2	5	4		1	11	4	12
Subtraction											
8-2	6	3		1	1	1		9	3	1	12
12-5	5	1	1	2	3			7	5	1	12
23-18	3		1	3	5			4	8	1	12
467-43	1	3		3	4	1		4	8	1	12
305-97				3	5	4		0	12	4	12
Multiplication											
2x4	5	2		3	2			7	5	0	12
5x3	4	2		4	2			6	6	0	12
12x4	1	2	1	6	2			4	8	1	12
24x6				7	4	1		0	12	1	12
120x5				3	5	4		0	12	4	12
Division											
6÷3	5	1		1	5			6	6	0	12
18÷2	2	1		2	7			3	9	0	12
24÷3		1	1	3	7			2	10	1	12
75÷3		1		3	8			1	11	0	12
120÷15					8	4		0	12	4	12
	51	30	4	52	84	19	0	85	155	23	240

Figure 8: Pre-assessment method data entry for one club (Club A)

Summary of learner methods in the 4 operations post assessment											
	School/club code	Club A			Number of learners			12			
	Frequency of...							Totals			
Problem	Correct answers without written working	Correct answers with written NON-TALLY working	Correct answer using TALLIES	Wrong answer without written working	Wrong answer with written workings	Wrong answer using TALLIES	Not answered	Number of correct answers	Number of wrong answers	Number of answers using tallies	Check column (no. of responses must equal number of learners)
Addition											
3+4	12							12	0	0	12
8+6	12							12	0	0	12
23+18	8	4						12	0	0	12
55+67	4	6			2			10	2	0	12
104+97		8		2	2			8	4	0	12
Subtraction											
8-2	11			1				11	1	0	12
12-5	12							12	0	0	12
23-18	7	4		1				11	1	0	12
467-43	4	8						12	0	0	12
305-97	2	8		2				10	2	0	12
Multiplication											
2x4	11			1				11	1	0	12
5x3	11			1				11	1	0	12
12x4	6	3		1	2			9	3	0	12
24x6	6	5		1				11	1	0	12
120x5	1	2		4	5			3	9	0	12
Division											
6÷3	9			3				9	3	0	12
18÷2	9			3				9	3	0	12
24÷3	6	3		3				9	3	0	12
75÷3	4	3		3	2			7	5	0	12
120÷15	2	2		3	5			4	8	0	12
	137	56	0	29	18	0	0	193	47	0	240

Figure 9: Post-assessment method data entry for one club (Club A)

3.9 Data analysis

There is no clear point at which data collection stops and data analysis starts in a qualitative research study (Kelly, 2006). Various authors (Macmillan & Schumacher, 2010; Durrheim 2006; Neuman, 2011) point out that data analysis takes place simultaneously with data collection. At the same time Srivastava (2009) points out data analysis in qualitative research is an iterative process and thus the data analysis strategy, just like the entire data collection strategy, can be altered as the research inquiry unfolds.

Learner progression in mathematical proficiency and number sense

I used both qualitative and quantitative data analysis methods to analyse the four operations data. Firstly, I quantitatively analysed the four operations pre and post assessments by looking at the overall change in the four operations across the five clubs. Secondly, I reviewed the scores for each operation in each of the five clubs as well as the average over change for the clubs.

Thirdly, I compared the pre and post test scores of each individual learner in each of the five clubs. The aim was to check whether any change between the two is apparent by looking at the percentage point changes and in pursuit of answering research question one. The summary of change in each individual club by operation will be tabulated and discussed further in the Section 1 of Chapter Four.

Fourthly, I analysed the changes in methods used by the learners by reviewing the data calculated from the spreadsheets discussed above. The aim was to see possible change in methods used by learners in pursuit of responding to research question 1. Then I analysed the change in club learners per club and summarised the change in all five clubs using the following categories. I made the decision to focus just on the methods used for correct answers and I wished to examine the relationship between the changes in learner scores and the methods they'd used to achieve those scores.

In the presentation of this data in Chapter Four, you will notice that the change in responses is expressed as either a negative or positive number. The meaning of such change is described in each category below:

1. Correct responses with no shown workings

Positive responses indicate that more club learners could arrive at an answer without any workings shown. Ideally, I am looking for more positive changes in this column since by the end of Term 2, grade 6 learners are expected to compute at least 6- digits successfully (DBE, 2011b p.14). Many of the problems in this assessment could be worked with mental strategies as well.

Negative responses indicate that few club learners would show their workings and most of the club learners used other methods to arrive at an answer.

2. Correct responses using non-tally methods

Positive responses mean that more club learners have used other strategies such as traditional algorithm, doubling, halving, decomposition of numbers into place values, etc. to arrive at an answer. Ideally more club learners would use these more efficient (less constrained) strategies on more difficult items and could compute more easily and fluently irrespective of the number size and range. A negative change means that less club learners do calculations using these methods even on easy numbers with single or double digits which might show less change in progression on mathematical proficiency.

3. Change in responses using tallies[3]

Positive responses show that more learners rely on perceptual unit counting especially the use of tally marks, circles, drawings of any kind and counting using finger (which was been noted by club facilitators while learners were writing the assessment tests). Negative responses show that fewer club learners used such constrained and less efficient methods. Preferably learners by this grade (6) should not be using tallies so a 0% or negative responses would be ideal and that would mean that club learners have progressed to flexible and fluent methods of counting.

I then compared the learner scores and methods in order to show how the overall percentage change happened and intertwine with the change in learner methods as indicated in the club learner responses. I have looked at the amount of club learners shown change in each category discussed above club by club versus the number of scores obtained.

Finally, I illuminated learner's change in performance on the pre- and post- assessments using specific learner's vignettes to support the data discussed above from each club. For each learner I present the time they have spent on both assessments, the score obtained on each of the four operations and the learner's final score to see if any quantifiable change is there. I then mapped the learner methods on the spectra to see where there were eminent changes on learner response and in whether such change indicated if learners have progressed or not will be discussed in the next chapter. Remember qualitative

[3] Tallies in this study include all perceptual unit counting methods involving circles, tally marks, drawings of any kind and use of fingers (that was noted by club facilitators while the learners were writing the pre- and post-assessments).

analysis took place based on the methods used by the learners as evident on both pre and post-tests spectra and as discussed above. Because of this analysis, learner cases were highlighted and were useful to discuss with the teachers in the 1-1 interviews.

Post-Club teacher questionnaires and one-to-one interviews

To make sense of the qualitative data, I grouped relating inferences from the teachers as themes. I used such themes for the analysis of the data in this research. Braun and Clarke (2006) believed that even if there is no clear agreement about what thematic analysis is and how to go about doing it, it is widely used in qualitative research. Hence thereof, for the purposes of this discussion thematic analysis can be defined as a research data analysis method that enables the researcher to determine the relationship between concepts by identifying, analysing and reporting on themes or patterns in the research text or data (Alhojailan, 2012; Braun & Clarke (2006); Attride-Stirling, 2001).

Braun and Clarke (2006) maintains that thematic analysis is flexible, enables the researcher to report on the "experiences, meanings and the reality of participants and allow the researcher to present a rich analysis of data. To such an extent that it places a great demand on the researcher to provide the reader with details on how data analysis was carried out. Braun and Clarke (2006) also emphasised that "if we do not know how people went about analysing their data, or what assumptions informed their analysis, it is difficult to evaluate their research" (p.7).

The teachers' responses to both questionnaire and interview questions were tabulated with respect to the question item they were asked. The aim of tabulating the responses as in Table 3 below, was to spot any commonalities and to be able to group them according to emerging themes. See Appendix 5 for tables a, b to h.

Table 3: A sample of coding of club facilitators' responses on item 1 of the post-club teacher questionnaire

Item 1: Can you describe how you felt as a facilitator in the club space?

Respondents	Response category	Responses
CFA1[4]:	Relevant	*"I felt good because I change learner's attitude in Mathematics"*
CFB1:	Relevant	*"It made me feel empowered and strengthened the training I received as a Mathematics teacher"*
CFC1:	Relevant	*"I felt relaxed at the beginning as time goes by I felt confident as the group number (referring to club size) could be easily manageable and give individual attention to the others (referring to club members)"*
CFD1:	Relevant	"*Very honoured to work with learners who encountered learning problems as someone who had remedial experience on how to deal with them I gained more idea to add on that I have which are more enjoyable to the learners and easy to understand.*
CFE1:	Relevant	"*I felt privileged and honoured! I felt that here is an opportunity for me to make a change in kid's life (In their Mathematics life)"*

From these tables I found that some club facilitator's responses did not answer exactly the questions they were asked. Instead, they would just express how they and the club members felt about being in the club space; the impact of the club games in learners' shifts in attitude, confidence, participation, thinking, computation within and after participating in the clubs. I became more interested in how exactly these shifts were realised in pursuit of responding to research question two. I realised that the items on the pre-questionnaires were so silent in that regard and that gave me food for thought in drafting and framing the teacher interview questions.

Across all respondents and their answers, I grouped, and colour-coded consistencies identified. Four themes emerged from such groupings as:

1. Learning environment (referring to the club space);
2. Learning approach;
3. Learners' participation and attitude; and
4. Change in learners' mathematical proficiency.

All these themes will be further discussed in the next Chapter of Findings.

[4] CFA1 represents the first (1) club facilitator (CF) of club A. A similar notation has been used for Clubs B, C, D and E.

3.10 Evaluating the quality of this research

In qualitative research, there are many ways to evaluate the quality of a research study. This research has employed multiple strategies to ensure and enhance validity and reliability of the data.

The research instrument (i.e. the four operations assessment) used to collect learner progression data has been used in the broader SANC project over the last seven years to assess over 1500 learners a year. Thus, this instrument has proven to be effective for the assessment of learner progression as required by this study.

The assessments are derived from the Early Grade Mathematics Assessment (EGMA) which is a model designed to provide simple low-cost measures of early mathematics skills. Their role is to identify difficulties in learners' school's experiences and provide the opportunity for remediation in the early grades. EGMA instruments represent a progression of foundational skills that support proficiency in mathematics. Note that they are used in this study as an instrument to assess learner's number sense and procedural fluency in this research. This is achieved by ensuring that learners show their workings in their scripts.

As indicated previously (section on mixed methods) I used *triangulation* (Koshy, 2005) by collecting data specific to this research study to add further dimensions to the data collected by SANC project using the methods as discussed above. The varied data collection methods produced both quantitative and qualitative data and I was able to cross check (triangulate) across these for coherence and possible disconnects. This enabled me to look at the research questions from a multiple perspective so as to enhance the accuracy of the findings (Neuman, 2011). Such triangulation also allowed for thicker description of the progression of learners and teacher's experiences of working with the learners in the club space.

After the one-to-one interviews were transcribed, I used member checking (Cohen et al., 2000). The transcripts were made available to the teachers interviewed so they could check that the transcripts reflected what they said. All the participants acknowledged their accuracy with no objections.

To ensure that conclusions made by means of this qualitative research are as accurate as possible, I was aware of what Maxwell (2012) calls "reactivity": the possible distortion caused by my own conceptions and values, as well as the effect that I may have had on the individuals and setting being studied Although the researcher as a "human instrument" brings unique characteristics to the data collection process, the

potential of bias and subjectivities should be identified and monitored (Merriam, 2002, p.5). I discussed these in relation to my positioning in the research earlier in the chapter.

3.11 Methodological dilemmas

Kvale (2009) and Hollway and Jefferson (2000) argue that the less structured the interview, the greater the risk of the interviewer introducing topics and views they consider important and shaping the interview in ways they don't understand. In an interview, what you already know is as important as what you want to know. What you want to know determines which questions you will ask. What you already know will determine how you ask them hence less structured questions are suggested to allow the interviewer such opportunity (Leech, 2002)

As I indicated previously, the aim of the one-to-one interviews was to ascertain the teachers' experience of learners' changing numbers sense and procedural fluency as a result of participating in the clubs and finally teachers' experiences of working with learners in the club space. The first round of one-to-one interviews was held between September and November 2017.

In spite of my best intentions at the beginning of the study, I realised when I was transcribing the teacher interviews in November 2017, that when interviewing the teachers, I sometimes led them too much with prompting rather than waiting long enough for the response. I thus decided to go back to the teachers for the second round of interviews in which I did less prompting and gave teachers more waiting time for responses. I would not have been able to re-negotiate a second interview with them without my good relationship with these teachers.

As a result, I arranged to have a second round of interviews between January and March 2018 with the club facilitators. This time I was aware of asking more open-ended questions in order to give them space and time to indicate what was happening in the clubs through discussion with myself as the interviewer. I wanted to provide a platform for them to feel relaxed to talk in-depth about their experiences and that of the learners and to elaborate on what they may have written on the post club teacher questionnaires. I gave them thinking time. At times the interviewees were silent, and I gave them enough time to think about the subject at hand. Then I would probe them, rephrase the question asked, ask for more details, pick up on interesting words, gestures and phrases or try to fill in the gaps. From time to time they would jump to another point and move away from the subject, then I had to refocus them to ensure that we stuck to what I as the researcher intended and to reduce the potential of the interviewee giving what Holloway and Jefferson (2000) call "unpredicted data". For instance, question 12 in the teacher interview

questionnaire asked how the learners interacted or worked together before and after club participation. The response was "they were shy before, but after you could see the smile in their faces" (CFC2, December 2016).

Additionally, I could not retrieve the audio recording of the interview with Club A Facilitator Two (CFA2) as the recorder I used during the interview failed me. So, I did not include his data in the findings in Chapter 4.

3.12 Concluding comments

In this chapter I discussed the research design and methodology of this study. I provided the overview of methodological orientation and framework for this study. I positioned myself as a researcher, then detailed the research timeline, described the intervention that ran over the 15-week period and included the data collection method and data analysis. Finally, I evaluated the quality of this study and presented the methodological dilemmas I accounted.

In the next chapter I discuss the findings.

CHAPTER 4: FINDINGS

4.1 Introduction

In this chapter I present the findings that relate to the pre- and post- baseline assessments results looking at the mathematical progression displayed by club learners on the SANC project's four operations (instrument Appendix 1). Secondly, I provide narrative vignettes of the teachers as club facilitators and transcribed extracts of club learners' progression and their experiences of working in the club space as transcribed from the semi structured interviews and post club questionnaires.

The data presented here is from the five club sites with 60 Grade 6 club learners and five facilitators with support from the other four mathematics teachers in their schools (only two of the supporters participated in the interviews). All club sites are situated in townships and the medium of instruction[5] is English except for the one school in Rosedale which is an Afrikaans medium of instruction school. Each of the five Grade 6 teachers ran clubs in their respective schools with 12 learners resulting in a total sample of 60 learners. As mentioned previously the learners were selected from a broader pool of low attaining (poor performing) learners who showed interest in participating in the clubs.

4.2 Section 1: Findings from learner 4 operations pre- and post-assessments

Research question one explores the progression changes evident in club learners' mathematical proficiency over the period of club participation. Recall that for the purposes of this study, my focus is on procedural fluency and number sense. In pursuit of responding to this research question, I have segmented this section into three parts that comprises of three different approaches to the analysis of the four-operations data collected from the clubs. The first part looks at scores and percentage changes from a quantitative point of view. The second part examines detailed changes in the methods used by the club learners in their responses in pre and post assessments. The third part presents detailed learner vignettes that unpack some aspects of these figures more qualitatively and give examples of learner workings.

[5] Medium of instruction: Language of Learning and Teaching (LoLT)

Section 1.1 Scores and percentage changes

1.1.1 Overall change in the four operations for all five clubs

The graph in Figure 10 below is a summary of the scores for all 60 club learners across the five Clubs. The club learners show the biggest average percentage point change in multiplication (27%), although there are pleasing changes across all operations, with an overall average change of 25 percentage points across the four operations (Figure 10 below). This reveals that club learners on average successfully completed five more questions (5 out of a possible total of 20 is 25%) in the post-assessment than in the pre-assessment.

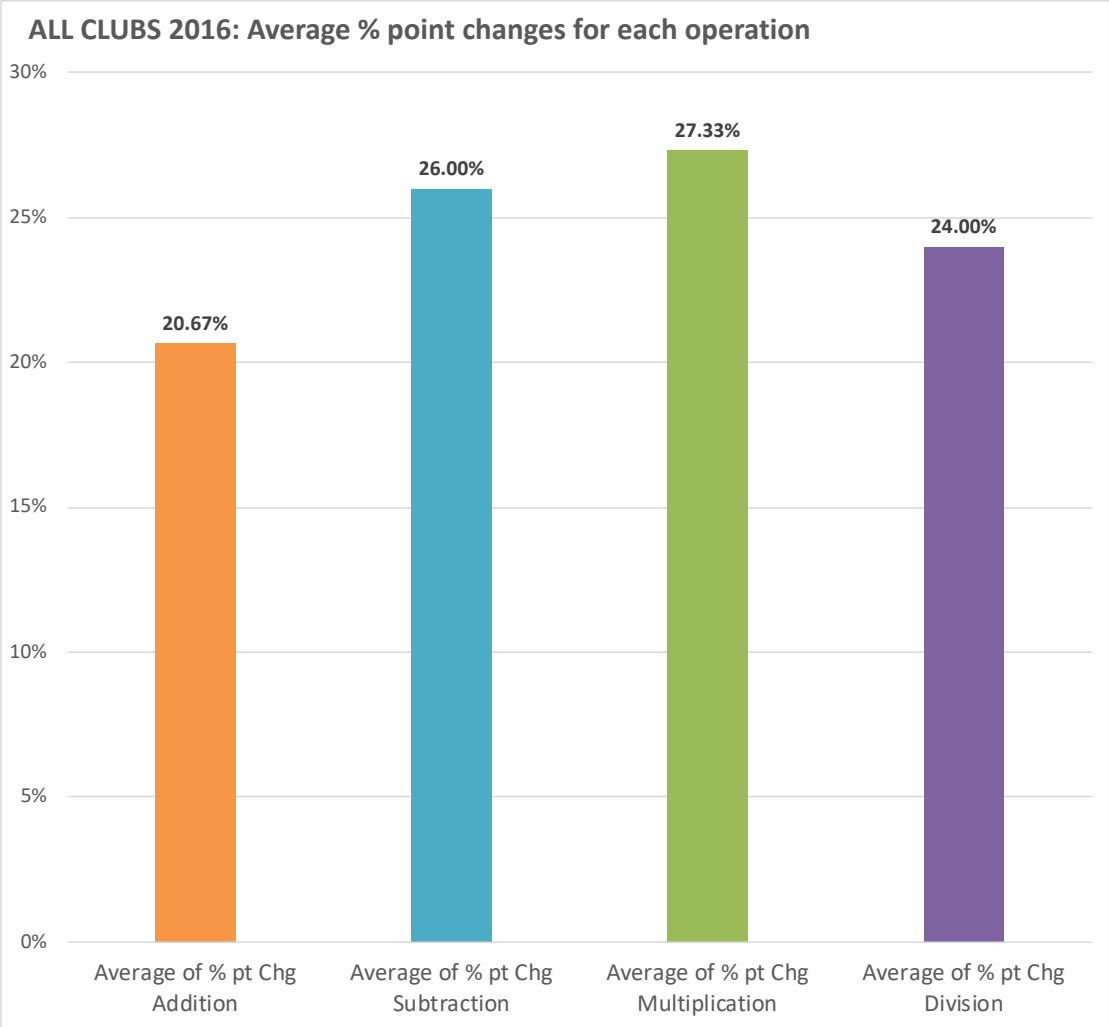


Figure 10: Overall average percentage score changes for all 60 club learners across the five clubs

1.1.2: Individual club changes

Table 1 below shows the scores for each operation in each of the five clubs as well as the overall average change for all the clubs. The percentages show the change between the pre- and post- assessments. Club A has an overall average change of 43%. This is relatively evenly spread across the 4 operations, although the biggest increase is with 55% in multiplication. The changes for Club B are similar to Club A with the overall average of 39%. The biggest increase is 42% for both addition and division. Club C however, shows a slightly different story. The overall average change is lower at 10% and no change in scores is shown for addition and subtraction. Multiplication and division show less change than Clubs A and B, but it is still change.

Club D has the lowest overall average change of all the Clubs with 9% point change. The change for division shows a negative 5%point change, which indicates that the club learners answered less division problems correctly in the post assessment test than in the pre-assessment test. The changes for Club E are different than the other four with the overall average change of 22% point change. The smallest average percentage of 3% point change is with addition and the biggest change of 35% point change is with subtraction. I explored the possible reasons for these changes in the next section when I look at the methods learners used to answer problems.

Table 4: Summary of % point change in each club by operation

Club	Average % point Chg. Addition	Average % point Chg. Subtraction	Average % point Chg. Multiplication	Average % point Chg. Division	Average Overall % point Chg.
Club A	32%	47%	55%	40%	43%
Club B	42%	38%	33%	42%	39%
Club C	0%	0%	22%	17%	10%
Club D	27%	10%	3%	−5%	9%
Club E	3%	35%	23%	27%	22%
Total	21%	26%	27%	24%	25%

To support the overall data in Table 4, individual learner scores are included in the next section to show individual learner achievement per club.

Table 5 to Table 9 illustrate the pre- and post- assessment scores of each learner who participated in the club, including their point percentage change overall operation.

From Table 5 to 9, it is evident that 57 out of 60 learners who participated in the clubs show positive change between the pre-and post-assessment, ranging between −5% and 80%. This is reassuring given that at the start of the 15-week Programme, these learners attained scores that ranged between 0% and 15% when the pre- assessment was administered.

The number range of the items in the assessment (see Appendix 1) is from 1 to 3 digits which is far less than the 6 to 9 digits that these learners are expected to compute proficiently by grade 6. As these club learners are in Grade 6, they should, according to the curriculum, be able to achieve 100 percent for this assessment. The post-assessment scores of 57 learners which ranged between 3 and 20 indicate a reasonable progress in most clubs. Club Learners, D47, E53 and E50 regressed by either a score of 1, 2 or 3 in the post-assessment, hence the negative percent point change.

1.1.3: Learner data for each club

Club A

Considering Table 5 below, the average score in the pre-assessment was 7 out of 20 (33%). The figures show a 43.3 percentage point improvement after the 15 weeks. In the post-assessment, the average score is 15 out of 20 (67%). Although none of the learners achieved 20 out of 20, five club learners (marked with a * in the table) achieved a 50 or more-percentage point change between the pre- and post-assessment. This equates to correctly answering between 10 and 15 more questions correctly out of the possible 20.

Table 5: Individual learner progress for Club A

**indicates learners who achieved a 50 or more % point change.*						% point change for…			
Learner Code	**Pre-score**	**Pre % Score**	**Post- score**	**Post % Score**	**Overall % point change**	**Add**	**Subtract**	**Multiply**	**Divide**
A1*	2	10.0%	17	85.0%	75.0%	20.0%	100.0%	80.0%	100.0%
A2	0	00.0%	6	30.0%	30.0%	80.0%	40.0%	0.0%	0.0%
A3	13	65.0%	18	90.0%	25.0%	40.0%	20.0%	20.0%	20.0%
A4*	3	15.0%	13	65.0%	50.0%	60.0%	60.0%	80.0%	0.0%
A5	15	75.0%	17	85.0%	10.0%	0.0%	0.0%	60.0%	-20.0%
A6*	8	40.0%	20	100.0%	60.0%	40.0%	60.0%	40.0%	100.0%
A7	2	10.0%	11	55.0%	45.0%	40.0%	80.0%	60.0%	0.0%
A8	10	50.0%	15	85.0%	35.0%	0.0%	20.0%	80.0%	40.0%
A9*	3	15.0%	18	95.0%	80.0%	60.0%	80.0%	80.0%	100.0%
A10	8	40.0%	11	55.0%	15.0%	-20.0%	40.0%	40.0%	0.0%
A11*	7	35.0%	17	85.0%	50.0%	0.0%	40.0%	80.0%	80.0%
A12	8	40.0%	17	85.0%	45.0%	60.0%	20.0%	40.0%	60.0%
Averages	7	32.9%	15	76.3%	43.3%	31.7%	46.7%	55 .0%	40.0 %

Club B

In Table 6 below, the average score in the pre-assessment is 7.2 out of 20 (35.8%) with a 38.8 percentage point change when compared with the 14.9 score out of 20 attained by the learners on the post-assessment. This indicates positive progress by the club learners after participation in the 15 weeks of the PfP Programme. Unlike club A, only two learners scored a percentage point change increase of 50% or more (B13 and B22).

Table 6: Individual learner progress for Club B

**indicates learners who achieved a 50 or more % point change.*						% point change for…			
Learner Code	**Pre-score**	**Pre % Score**	**Post-score**	**Post % Score**	**Overall % point change**	**Add**	**Subtract**	**Multiply**	**Divide**
B13*	9	45.0%	19	95.0%	50.0%	0.0%	40.0%	100.0%	60.0%
B14	11	55.0%	14	70.0%	15.0%	20.0%	0.0%	20.0%	20.0%
B15	11	55.0%	16	80.0%	25.0%	20.0%	20.0%	40.0%	20.0%
B16	0	0.0%	7	35.0%	35.0%	80.0%	60.0%	0.0%	0.0%
B17	4	20.0%	12	60.0%	40.0%	40.0%	40.0%	40.0%	40.0%
B18	6	30.0%	14	70.0%	40.0%	60.0%	60.0%	20.0%	20.0%
B19	9	45.0%	16	80.0%	35.0%	40.0%	40.0%	0.0%	60.0%
B20	8	40.0%	17	85.0%	45.0%	60.0%	60.0%	20.0%	40.0%
B21	10	50.0%	17	85.0%	35.0%	0.0%	40.0%	20.0%	80.0%
B22*	3	15.0%	15	75.0%	60.0%	80.0%	60.0%	60.0%	40.0%
B23	8	40.0%	16	80.0%	40.0%	20.0%	20.0%	40.0%	80.0%
B24	7	35.0%	16	80.0%	45.0%	80.0%	20.0%	40.0%	40.0%
Averages	7.2	35.8%	14.9	74.6%	38.8%	41.7%	38.3%	33.3%	41.7%

Club C

In Table 7 below, the average score in the pre-assessment is 6.9 out of 20 (34.6%) with a change of 9.6 percentage points when compared with the 8.8 score out of 20 attained by learners in the post-assessment. Although much of this is positive progress, it is less than that of Clubs A and B and note no learner obtained a 50% or more % point change.

Table 7: Individual learner progress for Club C

						% point change for…			
Learner Code	Pre-score	Pre % Score	Post- score	Post % Score	Overall % point change	Add	Subtract	Multiply	Divide
C25	6	30.0%	13	65.0%	35.0%	40.0%	0.0%	40.0%	60.0%
C26	3	15.0%	3	15.0%	00.0%	-20.0%	0.0%	20.0%	0.0%
C27	10	50.0%	16	80.0%	30.0%	0.0%	40.0%	40.0%	40.0%
C28	4	20.0%	9	45.0%	25.0%	40.0%	20.0%	40.0%	0.0%
C29	8	40.0%	7	35.0%	05.0%	0.0%	-20.0%	0.0%	0.0%
C30	7	35.0%	13	65.0%	30.0%	20.0%	20.0%	0.0%	80.0%
C31	10	50.0%	8	40.0%	10.0%	60.0%	20.0%	0.0%	0.0%
C32	6	30.0%	5	25.0%	05.0%	20.0%	-20.0%	-20.0%	0.0%
C33	9	45.0%	9	45.0%	00.0%	0.0%	0.0%	0.0%	0.0%
C34	6	30.0%	4	20.0%	10.0%	-40.0%	-40.0%	40.0%	0.0%
C35	10	50.0%	11	55.0%	05.0%	-20.0%	0.0%	40.0%	0.0%
C36	4	20.0%	8	40.0%	20.0%	20.0%	-20.0%	60.0%	20.0%
Averages	6.9	34.6%	8.8	44.2%	9.6%	0.0%	0.0%	21.7%	16.7%

Club D

Club D has indicated in

Table 8 a positive progress as well of 8.1% out of 20 (40,4%) with change of 1.7 percentage points when compared with the 9.8 score out of 20 attained by learners in the post- assessment. As with Club C no learner scored an average % point change of 50 or more. Although this data does not show substantive positive progress, it is similar to the progress made by Club C.

Table 8: Individual learner progress for Club D

						% point change for…			
Learner Code	Pre-score	Pre % Score	Post-score	Post % Score	Overall % point change	Add	Subtract	Multiply	Divide
D37	1	05.0%	6	30.0%	25.0%	60.0%	40.0%	0.0%	0.0%
D38	10	50.0%	11	55.0%	5.0%	20.0%	0.0%	0.0%	0.0%
D39	8	40.0%	9	45.0%	5.0%	20.0%	40.0%	0.0%	-40.0%
D40	13	65.0%	14	70.0%	5.0%	40.0%	0.0%	0.0%	-20.0%
D41	8	40.0%	8	40.0%	0.0%	0.0%	0.0%	0.0%	0.0%
D42	11	55.0%	11	55.0%	0.0%	20.0%	-20.0%	0.0%	0.0%
D43	9	45.0%	11	55.0%	10.0%	40.0%	20.0%	0.0%	-20.0%
D44	6	30.0%	10	50.0%	20.0%	20.0%	40.0%	20.0%	0.0%
D45	10	50.0%	12	60.0%	10.0%	0.0%	-20.0%	20.0%	40.0%
D46	9	45.0%	9	45.0%	0.0%	0.0%	0.0%	0.0%	0.0%
D47	11	55.0%	10	50.0%	-5.0%	20.0%	-20.0%	0.0%	-20.0%
D48	1	5.0%	7	35.0%	30.0%	80.0%	40.0%	0.0%	0.0%
Averages	8.1	40.4%	9.8	49.2%	8.1	26.7%	10.0%	3.3%	-5.0%

Club E

In Table 7 below, the average score in the pre- assessment is 8.1 out of 20 (40.4%) with change of 22.1% percentage points when compared with the 12.5 score out of 20 attained by learners in the post-assessment which is also a positive percentage change. In this club also, as in club B, two learners (E50 and E54) scored more than 50% point increases.

Table 9: Individual learner progress for Club E

**indicates learners who achieved a 50 or more % point change.*						% point change for…			
Learner Code	**Pre-score**	**Pre % Score**	**Post-score**	**Post % Score**	**Overall % point change**	**Add**	**Subtract**	**Multiply**	**Divide**
E49	11	55.0%	15	75.0%	20.0%	0.0%	20.0%	40.0%	20.0%
E50*	6	30.0%	18	90.0%	60.0%	40.0%	100.0%	40.0%	60.0%
E51	4	20.0%	6	30.0%	10.0%	-20.0%	80.0%	-20.0%	0.0%
E52	4	20.0%	4	20.0%	0.0%	20.0%	-40.0%	20.0%	0.0%
E53	11	55.0%	8	40.0%	-15.0%	-60.0%	-40.0%	40.0%	0.0%
E54*	0	0.0%	16	80.0%	80.0%	80.0%	80.0%	80.0%	80.0%
E55	12	60.0%	18	90.0%	30.0%	0.0%	20.0%	40.0%	60.0%
E56	15	75.0%	16	80.0%	5.0%	-20.0%	20.0%	0.0%	20.0%
E57	5	25.0%	11	55.0%	30.0%	40.0%	40.0%	20.0%	20.0%
E58	10	50.0%	13	65.0%	15.0%	-40.0%	80.0%	0.0%	20.0%
E59	11	55.0%	19	95.0%	40.0%	20.0%	60.0%	0.0%	80.0%
E60	8	40.0%	6	30.0%	-10.0%	-20.0%	0.0%	20.0%	-40.0%
Averages	8.1	40.4%	12.5	62.5%	22.1%	3.3%	35.0%	23.3%	26.7%

1.2 Learner method findings

As indicated in chapter 3, I conducted a micro analysis of methods used by the club learners by comparing both pre- and post- scripts for all club learners. The figures in Table 10 have been calculated by analysing only the responses for *correct* answers from all learners in each of the 4 operations. As indicated in Chapter Three, there are 240 possible responses per club per problem (12 club learners x 20 items = 240 responses). Please refer to the section in Chapter Three for more detail of this analysis. Table 10 below presents the summary of club learners' responses for each club.

Table 10: Summary of the change in club learners' methods between pre- and post-assessments

Number of correct responses… of 240 possible responses

	with no shown workings			using non-tally methods			using tally methods		
	Pre	**Post**	**Change**	**Pre**	**Post**	**Change**	**Pre**	**Post**	**Change**
Club A	51	137	86	30	56	26	4	0	-4
Club B	48	27	-21	37	155	118	0	0	0
Club C	54	83	29	8	10	2	19	11	-8
Club D	59	65	6	25	56	31	9	8	-1
Club E	62	92	30	26	57	31	18	0	-18
Overall Averages	54.8	80.8	26	25.2	66.8	41.6	10	3.8	-6.2

The overall averages show an increase in no shown workings (+26) and the use of tally methods has gone down by 6.2 on average. The biggest change is in the use of non-tally methods with an average increase of +41.6 responses.

Club A learners gave more correct answers (an increase of 84 responses) in the post-assessment without showing workings. There was also an increase in responses using non-tally methods (+26). Of note is that were no tally mark responses used in the post-assessment.

Club B has no responses using tally methods for either the pre or post-assessment and shows a decrease of 21 less responses without shown workings. There is an increase of 118 responses using non-tally methods; 64% of the total 240 responses. This indicates where this club has made the most progress.

The responses for Club C show a slight decrease (-8) in tally responses, a slight increase (+2) in non-tally methods and an increase of +29 in no shown workings. Club D similarly has less significant changes (+6; +31; -1) respectively. Club E shows 18 less responses in using tally methods and +30 and +31 for no shown workings and non-tally methods respectively.

What do the score and method findings tell us when combined?

Here I compare the overall percentage changes (Table 1) with the changes in learners' methods (Table 3) to reveal any trends in the findings. Looking at Club A, the overall change of 43% may be a result of more club learners giving responses without showing workings (+86) and using non-tally methods (+26).

Club B's overall change of 39% could be as a result of using non-tally methods (+118) to work out answers to the assessment items. In Club C, there is a 10% change overall, which is the second lowest. This change is supported by the relatively small changes in responses for no shown workings and tally methods and the increase in the use of non-tally methods.

Similarly, in Club D the 9% overall change is supported by an increase of (+31) in using non-tally methods. Finally, in Club E the overall 22% change corresponds with increases in responses for no shown workings (+30) and non-tally methods (+31) and a decrease in tally mark methods.

These changes will be discussed in more detail in the context of broader data in Chapter 5.

Section 1.3 Detailed learner vignettes providing deeper analysis into the above data

In this section I aim to support the data showing learners' score changes over time by sharing richer, more detailed data from selected learners, derived from their workings on the assessment scripts. As Stott and Graven (2012) argue, progress in procedural fluency cannot be gauged only by looking at a single item from an assessment or by looking purely at scores. Indeed, fluency and number sense are defined in terms of ways of working with number and operations and not in terms of accuracy of answers. Therefore, I include a summary of the methods used by selected learners, across all 20 assessment items in both the pre and post-assessments (Table 11 below). This allows me to analyse and illuminate the overall shifts in methods used by the learners between the pre and post-assessments. This is then supported by a number of examples of learners' responses and answers from their scripts to explore and illuminate the shifts further.

I have selected several examples from learners written workings across the five club sites to illuminate the nature of learner progression in terms of fluency in methods. I chose those club learners that progressed in scores and in more flexible methods used. I have not chosen any learner in club E because I could not find learners with methods that show progression in their workings.

Table 11: Summary of number of responses for each spectra level for selected learners across all 20 assessment items (pre and post-assessment)

	←			→	
	Constrained[6]	**Less constrained**	**Semi fluent**	**Flexible, fluent**	**No. responses to assessment items**
Learner A1					
Pre	18			2	20
Post	2	3	4	11	20
Learner A6					
Pre	18	2			20
Post		2	6	12	20
Learner C27					
Pre	9	1		10	20
Post	7	2		11	20
Learner B13					
Pre	5	3	2	1	20
Post	5	5	5	4	20
Learner D40					
Pre	3	4	2	4	20
Post	5	4	2	3	20

As described in Chapter 3, the spectra incorporate elements of both number sense and procedural fluency, hence learners are placed at a particular level if the method used reveals lack of number sense and / or fluency and flexibility. For example, these responses from Learner A1's pre-assessment, show a lack of number sense and they have been allocated as **constrained methods**.

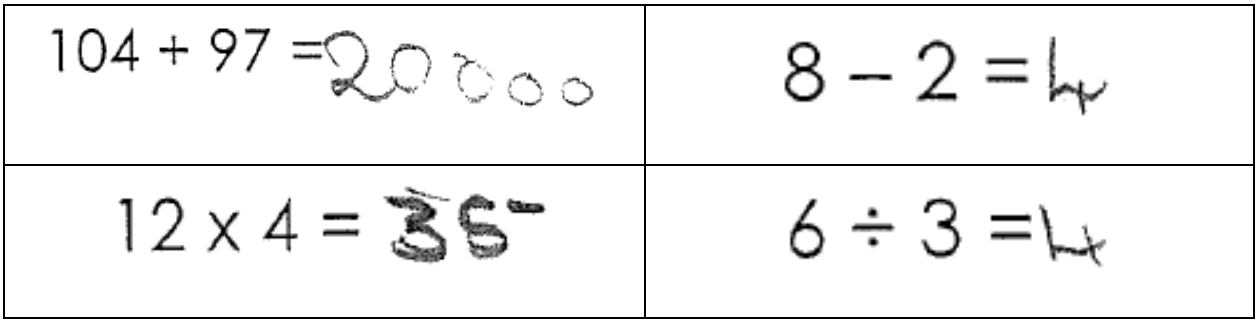


Figure 11: Example - Learner A1 pre-assessment responses

[6] Refer to Figure 1 for descriptors.

Learner A1 from Club A

In Club A, 10 out of the 12 club learners scores show positive change between the pre- and post-assessments. A5 was the most improved learner but I have selected A1 based on the methods she used to solve a subtraction problem. She spent less time on the post- assessment by 10 minutes and increased her score from 3 out of 20 to 17 out of 20 (see Table 12 below).

Table 12: Learner A1 scores on operations and time spent on assessments

	Assessment completion time	Addition	Subtraction	Multiplication	Division	Total score
Pre	27 minutes	2	0	1	0	3/20 (15%)
Post	17 minutes	3	5	4	5	17/20 (85%)

The pre-assessment shows that this learner predominantly used constrained methods (18 responses in Table 11). In the post-assessment, the types of methods used are more diverse, with a significant increase in flexible, fluent methods from two to 11 responses. I share this learner's responses to the five subtraction items to illustrate this shift. Also, the time it took the learner to both assessments. Note that the learner spent 10 minutes less on the post-assessment than the post. The shorter time indicates that perhaps the learner is more fluent and has a shifted number sense.

In the pre-assessment, all items were incorrectly answered, and the learner did not show any workings as shown in Figure 12. I note that the learner was unable to answer the first two subtraction items (2.1 and 2.2 in Figure 12 below) which should be known by a Grade 6 learner as basic facts. It is difficult to discern any connection between the answer and the question, which may lead us to assume that the learner guessed the answers. This reveals a lack of fluency (not knowing the basic facts) but also a lack of number sense, in that estimating answers is one of the key aspects of number sense. I can see that there is little awareness of estimating answers here, based on the numbers in the problem.

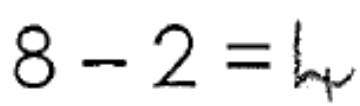
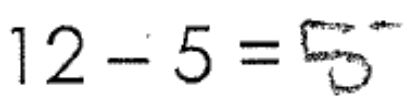
Item 2.1 pre-assessment	Item 2.2 pre-assessment
	

Figure 12: Learner A1 – Pre-assessment subtraction questions 1 & 2 (items 2.1 & 2.2)

In the post-assessment, however the first three subtraction items were answered correctly, without any shown workings, perhaps indicating some recall of facts which were now known. The learner used a

number line representation to approach the two more difficult questions with a bigger number range i.e. 467 – 43 and 305 – 97 (items 2.4 and 2.5 respectively) as shown in Figure 13 below.

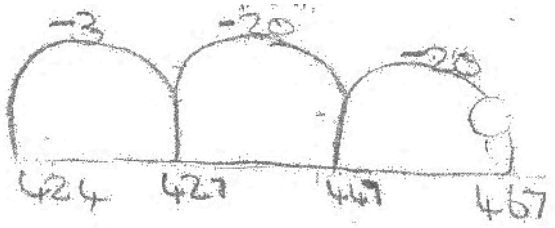
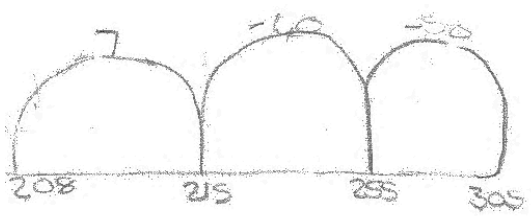
Item 2.4 post-assessment	Item 2.5 post-assessment
	

Figure 13: Learner A1 – Subtraction questions 4 & 5 (items 2.4 & 2.5)

For item 2.4, the learner broke the 43 into 20, 20 and 3 and jumped backwards on the number line to get the correct answer of 424. For item 2.5, the learner broke 97 into 50 and 40 and then seven thus partitioning the number into chunks of tens then units. Item 2.4 could be calculated mentally, as no 'borrowing' is required, so the number line method is perhaps unnecessary. But the method does reveal an understanding of the structure of 43 as a number (20, 20 and 3) and of the idea of subtraction using a number line. Similarly, item 2.5 could be calculated using a compensation strategy (305 – 100 = 205, add on 3 to compensate to get 208), but the number line method does show an understanding of the structure of 97 and its place value components. These methods reveal number sense in that both number lines show the correct direction of movement backwards for subtraction and the structure of number.

In looking at the spectrum for addition and subtraction, I could say that this learner has moved from a constrained approach in the pre-assessment to somewhere between a semi-fluent and flexibly, fluent position in the post-assessment (with 15 responses overall). The learner knows some basic facts (showing fluency) and has another strategy (using a number line) for working out the more difficult items (exhibiting some number sense and flexibility).

Learner A6 from Club A

This learner progressed in all operations with a 60% percentage point change overall (see Table 5). She spent on 11 minutes less on the post-assessments 26 minutes rather than 37). While looking at both the pre- and post- assessments scripts for this learner I noted some regression in the methods she used (see figure 5).

Table 13: Learner A6 scores on operations and time spent on assessments

	Assessment completion time	Addition	Subtraction	Multiplication	Division	Total score
Pre	37 minutes	2	2	3	1	8/20 (40%)
Post	26 minutes	5	5	5	5	20/20 (100%)

The pre-assessment (Table 11) shows that this learner predominantly used constrained methods (18 responses) to answer questions. In the post-assessment, no constrained methods are visible and there is a large increase in flexible, fluent methods (12 responses). With this learner too, the shorter time perhaps indicates that the learner is becoming more fluent and has a strengthening number sense.

I use the multiplication items (Figure 14) from Learner A6 to show shifts. In the pre-assessment, the learner used a vertical column method to answer all the items. The first three items were correctly answered. However, 24 x 6 and 120 x 15 were incorrectly answered. It is difficult to ascertain where the learner went wrong in using the vertical method. Although it could be argued otherwise, for these numbers it might be quicker to answer both of these questions mentally.

In the post-assessment, item 3.4 (24 x 6) was correctly answered using the vertical method and the learner successfully used a grid multiplication method to solve item 3.5 (120 x 15).

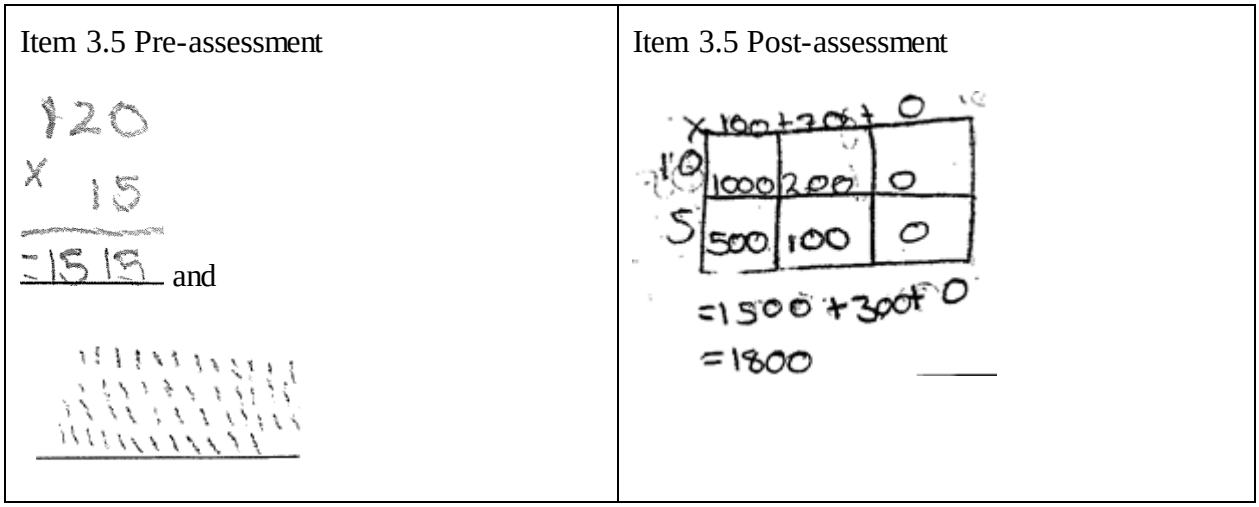


Figure 14: Learner A6 - Multiplication question 5 (item 3.5)

Although the grid method used for post-assessment item 3.5 could be considered a less fluent method as it could be worked out mentally[7], it displays improved accuracy, deeper number sense, particularly in

[7] using 120 x 10 = 1200; half of 120 = 600, giving a total of 1800

place value with the larger number range and fluency in known facts of multiplying by 10. The variety of responses (known facts, vertical column and grid method) used by this learner for answering these multiplication items in the post-assessment reveals an improved flexibility in selecting different methods or strategies to solve the different items, rather than simply relying on the vertical column method for everything.

Looking at this learner's complete set of responses for multiplication I suggest that in pre-assessment, the learner was fluent in some basic facts but working with a larger number range became tricky with these limited strategies. Thus, I could place the learner at the constrained end of the spectrum. In the post-assessment, I see a shift towards semi-fluent / flexible fluent methods overall.

Learner C27 from Club C

This learner progressed in all operations with a 30% percentage point change overall (see Table 14). S/he spent on 13 minutes less on the post-assessments. While looking at both the pre- and post- assessments scripts for this learner I noted some slight progression in the methods s/he used (see figure 16).

Table 14: Learner C27 scores on operations and time spent on assessments

	Assessment completion time	Addition	Subtraction	Multiplication	Division	Total score
Pre	38 minutes	5	2	2	1	10/20 (50%)
Post	25 minutes	5	4	4	3	16/20 (80%)

The pre-assessment methods (Table 11) shows that this learner used an almost equal mix of constrained methods (9 responses) and flexible, fluent methods (10 responses). In the post-assessment, slight increases are seen in less constrained and flexible, fluent methods. Looking at multiplication and division, in both the pre and post-assessments, the first two items in each operation were correctly answered without shown workings, indicating that perhaps this learner knows their basic facts and can retrieve them.

In the pre-assessment, multiplication items 3.3 and 3.4 (Figure 15 and Figure 16) were calculated using a mixture of tally marks and a vertical method, which looks like addition rather than multiplication. The post-assessment methods of repeated addition in vertical columns, gives correct answers.

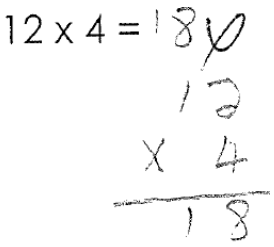
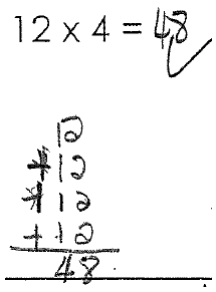
Item 3.3 Pre-assessment	Item 3.3 Post-assessment
	

Figure 15: Learner C27 - Multiplication question 3 (item 3.3)

Notably the learner was still using a column method but reverted to using repeated addition. One could argue that this is a regression, especially for a Grade 6 learner. However, the repeated addition shows some level of developing number sense, whereas the pre-assessment method makes no sense at all.

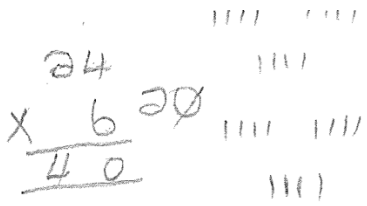
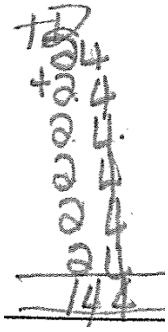
Item 3.4 Pre-assessment	Item 3.4 Post-assessment
	

Figure 16: Learner C27 - Multiplication question 4 (item 3.4)

Learner C27 incorrectly answered the fourth division question (item 4.4 in Figure 17) in the pre-assessment using a traditional algorithm. It is not clear what the operation is, but it could be subtraction, indicating that the learner does not understand the division symbol. In the post- assessment, she drew 75 circles and counted these off in groups of three to correctly answer the question.

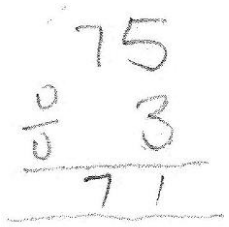
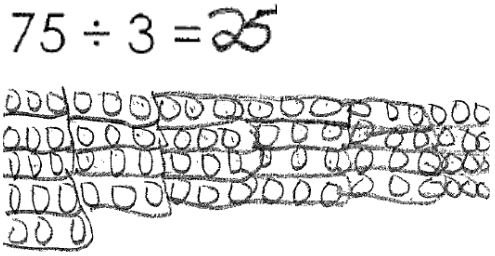
Item 4.4 Pre-assessment	Item 4.4 Post-assessment
	

Figure 17: Learner C27 - Division question 4 (item 4.4)

Even though the learner had a correct response in the post- assessment, we argue that this is not a fluent method for dividing 75 by 3. In Grade 6, learners are expected to use known division facts to answer this question. Alternatively, a learner with deeper number sense of division may use the inverse of known multiplication facts to get to the solution.

The responses to all the multiplication and division items in the pre-assessment reveal that the learner knows some basic facts which suggests fluency. However, the approaches used to answer the harder items indicates a lack of sense making and fluency. So, the learner could be said to be at a constrained level overall, for this grade. In the post-assessment, the knowledge of some facts remains (flexible fluency), interspersed with some semi-fluent methods for the more difficult items. One could place the learner at the semi-fluent position on the spectrum as both the multiplication and division methods used do show an emergence of sense making. The shorter time indicates that this learner too is more fluent and has a shifted number sense in computing some operations.

Learner B13 from Club B

Table 15 shows that this learner completed the post-assessment 8 minutes faster in the post-assessment (ie. 21minutes) and has a 50-percentage point change achieving full marks for addition, subtraction and multiplication in the post-assessment (Table 15).

Table 15: Learner B13 scores on operations and time spent on assessments

	Assessment completion time	Addition	Subtraction	Multiplication	Division	Total score
Pre	29 minutes	5	3	0	1	9/20 (45%)
Post	21 minutes	5	5	5	4	19/20 (95%)

I noted from the learners' scripts that it was common to use the vertical procedure incorrectly and inappropriately in both the pre- and post- assessments especially as a method for the last three items of every operation. However, this learner approached multiplication item 3.5 in both assessments. As indicated in Figure 18 below, he decomposed this number into place value horizontally. In the post-assessment his methods show a deeper understanding that he must decompose the multiplicand and not the multiplier and he correctly uses the brackets.

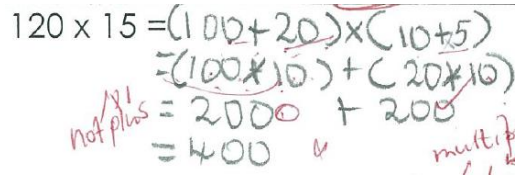
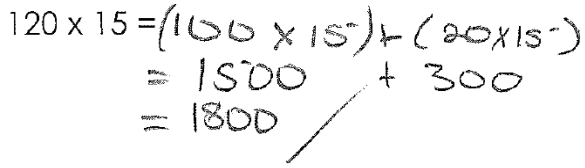
Item 3.5 Pre-assessment	Item 3.5 Post-assessment
	

Figure 18: Learner B13 – Multiplication question 5 (item 3.5)

Learner D40 from Club D

This learner shows change in addition only and scored one mark less in division in the post-assessment. The time spent on both assessments was not recorded in this club (Table 16).

Table 16: Learner D40 scores on operations and time spent on assessments

	Assessment completion time	Addition	Subtraction	Multiplication	Division	Total score
Pre	No time indicated	3	4	2	4	13/20 (65%)
Post		5	4	2	3	14/20 (70%)

Looking at the methods used by this learner on the pre- and post- assessments (Figure 19), there is no progress with respect to methods used. She used a tally method successfully in the pre-assessment and tried a different approach using an algorithm which yielded a wrong answer on the post-assessment. This method is not inappropriate and is unnecessary for this grade and number range. No progress was made in terms of methods on this operation.

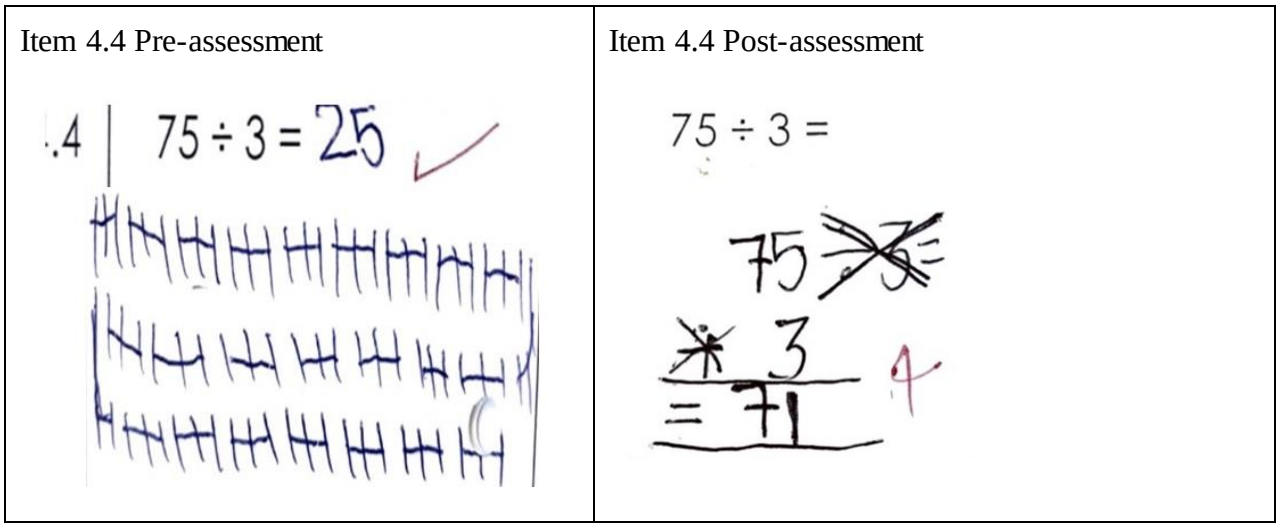


Figure 19: Learner D40 – Division question 4 (item 4.4)

Section 2: Findings from teacher's experiences of learners changing mathematical proficiency and of working in the club space

In this section I present descriptive, qualitative findings from i) the post club teacher questionnaire and ii) the teachers' responses to the semi-structured one-to-one interviews. Teacher questionnaires and interview transcripts were analysed in order to address research question three. The interviews aimed to collect deep, rich data on teachers' perspectives on their experiences of i) working with learners in the club space; ii) on their learners' progression and iii) their own experiences of working with learners with respect to the baseline assessment.

2.1 Findings from post club teacher questionnaire

As indicated in Chapter Three, I refer to the club facilitators (teacher participants) using their coded identity. Club facilitators' responses and reflections were coded according to relevance to the question asked without changes to spelling or grammar. These transcripts are given in tables 9a – h in Appendix 5. Teacher responses have been thematically coded into four themes and presented below.

2.1.1 Learning environment

All participants in this study expressed that it was the first time that they were in the club space and they felt good to be in such learning environment. Although their comments varied in length and detail, each of them stated in one way or another how they felt being in such a space and what it meant to them. I provide some samples of their comments.

> *Through being in the Clubs, I have learnt to make questions so fun, give clear instructions and make learners see joy and fun in mathematics. When learners are having fun, they interact more freely and respond to questions (CFA1, January 2017).*

> *The club environment enabled change, the atmosphere is so relaxed and informal, and learners work at ease. They enjoy being there. They have fun and learn through play (CFB1, January 2017).*

> *I felt empowered and learnt a lot of strategies that are mentioned in the CAPS I managed to use them since I didn't know, for example how to use the number line and the grid methods (CFB2, January 2017).*

> *I felt honoured and it was eye opener to experience the impact of club games and activities on learners CFC1, February 2017).*

There is more space to alleviate pressure from both members and the facilitator since we are playing (CFD1, February 2017).

Clubs are more of focused group thingy and allows the learners to work with numbers more comfortably (CFD2, February 2017).

CFE1: Learning through play in Clubs was a bit chaotic at first but later on it became an organised and fun chaos (CFE1, March 2017).

2.1.2 Learning approach

All participants described how they perceived the way the learners learn in the clubs. They also articulated how the game-based activities provoked learner thinking, the impact of working in a small group and in pairs and the role played by the pre-assessment. I provide below samples of their responses.

Activities are clear to follow and easy to explain to the learners. One covers a lot within one activity (CFA1, January 2017).

The small group enabled me to give individual attention when necessary and while the others are busy with their learning games. I got to know them more (CFB1, January 2017).

The pre-assessment helped to see which levels where the learners were with respect to operations (CFB2, January 2017).

Learners and I had an opportunity to work freely without any pressure in the clubs (CFC1, February 2017).

I have incorporated the games used in clubs in class as well to introduce new lessons and use them for mental mathematics. Learners love the "fizz pop" games (CFC2, February 2017).

Learners are more comfortable. Working in such a small group make forces them to participate and work with one another (CFD1, February 2017).

Activities are structured such that they give smooth transition for learners. Learners do not feel that the task is different or it's of a higher level compared to that which they did before (CFD2, February 2017).

The Programme does not feel intense as in class (CFE1, February 2017).

2.1.3 Learner participation and attitude

All participants mentioned something about how learners felt about being part of the clubs and how that impacted in their attitudes in mathematics. Each facilitator stated in one way or another that, "there is a difference in the learners' attitude in class". I provide a sample of their remarks.

> *They participate in class and want to be seen that they are part of the Clubs (CFA1, January 2017).*
>
> *Learners feel good, focused and excited when doing games (CFB1, January 2017).*
>
> *They enjoyed club games and they interacted more, no noisier as in class and they took the club spirit to the class (CFB2, January 2017).*
>
> *I notice they learn more with those cards, when they play, they concentrate, they are engaged (CFC1, February 2017).*
>
> *Clubs bettered my relationship with the learners. They are confident with mathematics now and their dignity is restored. Even if they give a wrong answer, they give it with confidence (CFD1, February 2017).*
>
> *No more fearing mathematics and bunking the classes now, their dignity is back (CFD2, February 2017).*
>
> *Learners are confident and no longer uptight, withdrawn, timid and passive (CFE1, March 2017).*

2.1.4 Changes in learner's procedural fluency and number sense

This was a common theme, expressed by all participants, often manifesting itself in discussions of how learners have improved in procedural fluency and sense making in mathematics.

> *They know now the answer quick. New strategies learnt from clubs made learners make sense of numbers and understand more. You can see it in their workings as well (CFA1, January 2017).*
>
> *They have improved a lot in mathematics. They count faster now (CFB1, January 2017).*
>
> *They do their homework now and not only from the clubs even the one I give from class. You can see it is not copied from others by the way the activity has been attempted. A variety of strategies are used, and they have a choice of using the one they like most like the number-line for subtraction and the grid method for multiplication (CFB2, May 2017).*

You can see a difference from those that are in mathematics clubs, they are on par with others in class (from level 1 to 3). They can now answer without being probed. There is a change in their performance too (CFC1, February 2017).

They are eager to work from their take home books and their responses are corrected. Even if you give the same problem in class and change number range, they get them right (CFD1, February 2017).

I could see measurable improvement in their results. Participation in the clubs revealed their capabilities. Activities in the Clubs stretched them and helped them improve (CFD2, February 2017).

They developed a love for the subject, and I say with confidence the clubs made them ready for grade 7. All 12 of them have progressed to grade 7 (CFE1, February 2017).

In the next section, I summarise and analyse the data from the one-to-one interviews with the teachers.

Section 2.2 Data from the one on one teacher interviews

In this section I present teacher responses from the semi structured, one-on-one interviews that I conducted with the five club facilitators and their four supporters who participated in the study. The interviewee responses have been grouped into the same four themes as the post club teacher questionnaires namely: learning environment, learning approach, learner participation and attitudes and change is learners number sense and procedural fluency.

2.2.1 Learning environment

This theme deals with the learning atmosphere and environment that prevailed during the club sessions at the various five club sites. In general, the club facilitators reiterated many of the claims they stated in the post club teacher questionnaire presented above. Many club facilitators used words like *nice, fun, felt good, enjoyed being in the club space, free, exciting, interesting games* and *relaxed atmosphere*.

Club A Facilitator One said she felt great since there were many teaching strategies and games she learnt to use in the clubs. She thought such strategies were easier than those used in the class. She stated that most of the activities led learners to think more quickly. When asked about her experience of being in the club space and her observations of the club learners in the club space, her response was:

I was excited and even the learners were so happy to be in the club space. After the second meeting, learners were so eager to work, no longer reserved unlike the first time. Even when you ask questions they responded and answered (CFA1, March 2018).

Such a response talks more to the third theme about learner's participation and attitudes. I will return to this later. When asked what she thought necessitated the excitement and eagerness, she responded by saying:

They are easier, fun and interesting. I am no longer strict and force them to use the strategy I am comfortable with. I let them use the one they understand. They are free to choose the strategy they like from a variety learnt from the Clubs even in the class. It's easy for them to learn now because they are learning by playing in the Clubs. The club games helped us (CFB1, March 2018).

Club B Facilitator Two attested that:

For me, the club space was an eye-opener, you know? First of all, we unleashed the talent that we didn't know that the kids had because they were so reserved. Usually these learners become so blank in class, then I try to avoid them so as not to expose them. I used to ask questions only the bright one's, then I go along with those that understand. Then I will see when in the test that they are lagging behind. At first, they were so reserved as Mrs X (referring to CFB1) has said. Later on, they gained confidence and noticed that the questions were brought to them, so they were forced to respond. Now they are all in the same level in the clubs. No bright learners to answer for them. The individualisation helped. (CFB2, March 2018).

Three of the other club facilitators also felt that the fact that the club size was small encouraged the shifts in learners. The facilitators claimed that they could give individual attention to the club learners, also learners had a platform to help one another, work together, share ideas and resources.

Club D Facilitator Two noticed that some of the learners who used to be withdrawn in class were now sociable in and out of the club space due to the attention paid to them and they participated fully in games played during clubs.

Club C Facilitator One made an interesting point about the duration of the club sessions and described how she adjusted the Programme to work for her and her learners. She observed that the learners became comfortable in a very short space of time but thereafter she had to make a lot of effort. Her learners

could not cope at first. They could not take instructions and the first session elapsed without her doing all what was planned for the day. She went back to her facilitator's manual and notes. She sat and prepared with the aim of redoing the activities of the day. She realised that if she had to repeat work, she would not finish within the stipulated fifteen weeks. She considered having two sessions a week instead of one. According to her, one hour was not sufficient as time was short during the club session.

She decided to select twelve mathematics buddies from learners in her class that are above average in mathematics. Their role was to sit next to the club members, explain the instructions to each club member "*not to overpower them. Don't do work for them but correct them" (CFC1. January 2018).* She had a preparatory session with the buddies twice a week, every morning on the Club session days. She decided to split the club members and the buddies between herself and the co-facilitator, to avoid having a big Club of 24 members.

> *That helped, I could easily finish the tasks of the day with the learners learning through play. Funny enough when they play, they concentrate. Learners are comfortable now, keen to work and with their listening skills improved. I have established leadership skills in buddies. (CFC1, January 2018).*

2.2.2 Learning approach

This theme elaborates on teacher facilitators' experiences of the impact of the club activities on both club learners and facilitators in and out of the club space. (i.e. during their school classes).

In the interview I asked how the teachers felt about extending and upping the game or activities during the club session as the participants did not respond well to this item in the post club teacher questionnaire. Club D Facilitator Two felt that in the club space was so relaxed, fun and interesting for both her and the learners and that she did not feel the intensity of the Programme. For her, the club sessions were well structured, focused and with clear and easy games and activities to follow. She observed that at times it was chaotic especially when the learners were so excited and did not want to wait for instructions and rush to figure out the game from the worksheets themselves. Then after her explanation it became an organised chaos.

Being in the club space made most of my work easier. I have learnt to give clear instructions and to make questions more fun, make it fun as in the Clubs. Be active but not uptight because I've seen learners learn more when they have fun. (CFD2, February 2018).

Club D Facilitator One mentioned that:

> *The activities are also well structured such that there is smooth transition for learners. Learners do not feel that the activities are at higher level than the one they have done before (CFD1, February 2018).*

Club E Facilitator One noted:

> *To me extending the learners meant that I had to stretch the learners more. To me it also meant differentiation, knowing what type of questions can be given to which learner. Usually that depends on the learner's ability and the capability of the teacher, but the clubs have proved me wrong. Activities were designed such that you can stretch every child (CFE1, February 2018).*

Recall that Club C Facilitator One introduced a buddy system. She noticed that:

> *The slow learners no longer bunk classes after participating in the clubs. They were usually bullied and teased because they could not cope or even write in other subjects. Now I use the buddies to help them even in my class. My class is so big with 46 learners I cannot pay attention to all of them. Even, the slow learners are on par with the others in class. But the Clubs are a lot of work for me since I have to prepare but I'm enjoying the benefits (CFC1, January 2018).*

When asked what benefits she was referring to, she responded by saying: "I am a remedial teacher now. My kids have moved from level one to three. They are no longer slow learners except for two of them. Those really needs referral they are special kids" *(CFC1, January 2018).*

2.2.3 Learner participation and attitudes

> *No one is shy for mathematics anymore. No fear of mathematics for them (CFA1, March 2018).*

This quote exemplifies how teachers perceives the changes in learner participation and attitude after participating in the clubs. Teachers responses indicated that learners had improved their participation, they could respond eagerly without being probed, they were now keen, excited, they enjoyed the clubs, they were very interested in them and were not reluctant to do clubs' homework.

When asked whether any evident significant change through learner participation in the clubs, the club facilitators responded positively as this example from Club C Facilitator One shows:

> *With a big Yes. Learners can answer without being probed. They participate. They want other kids to see that they are part of the clubs. They have a way of showing that. No longer bunking*

mathematics class. Their confidence and dignity are back. Even those learners that were withdrawn in class are interacting especially, D38 and D39 (CFD1, February 2018)

Club D Facilitator Two stated that "D39 was the most reserved learner in my class. Now she responds to questions. She would give a wrong answer with confidence" *(CFD2, February 2018).*

Club E Facilitator One had much to say about this.

The new-found love, respect for mathematics emerged in my class. The learners attitude changed. Especially with the boys. They compete against one another when it comes to their results. I know it's not encouraged in the clubs, but I could not stop it in my class outside the clubs. It was a healthy competition. It helped the rest to be serious and they improved. There was no pressure for the learners, the club size was small. There is one child who couldn't add, subtract, multiply or divide at all, she struggled with mathematics and hated it, but she progressed a lot. I can attribute such change to the fact that in the clubs there is no system of grading and she is under no pressure. I assigned a buddy to her. I have stolen that idea from Mrs X (referring to CFC1). It worked so well. Learners learn better from their peers. I think the extra hour helped, I have involved the parents too I have made them to sign the yellow homework books. That worked well for us too not a single learner did not participate. Even (referring to learner E59) (CFE1, January 2018).

2.2.4 Change in learner's number sense and procedural fluency

This theme explores the shifts noted by club facilitators in terms of their learners' procedural fluency, flexibility and making sense of numbers as a result of participating in the clubs.

Club A Facilitator One noticed that "most of the learners when they were writing the pre-assessment most of them used their fingers and lines to count but only few of them use their fingers now to count" (CFA1, March 2018). She claimed that those 'lines' (referring to tallies) are gone. When asked whether she could attribute such progress to the learners' participation in the clubs, she responded with "a big YES" (CFA1, March 2018). When asked as to what exactly it was about the clubs that initiated the shifts, she responded by saying: "The fizz-pop[8] and friendly numbers have helped the learners to add and

[8] Fizz-pop game: Was introduced to the club facilitators in the second workshop as a quick mental game used to focus and collect the club learners' mind so as to give an answer promptly and spontaneously. It is suggested for use at the beginning of a number of club sessions.

subtract nicely. Even with the bigger numbers and large number range in class (out of club space) learners could add without using lines and fingers" (CFA1, March 2018).

When asked why the fizz-pop game helped the club learners she mentioned that fizz-pop number bonds helped learners with addition, fizz-pop doubling and halving with division and multiplication. She recalled that the grid method (used in club sessions 13 and 14) helped with multiplication and gave a lengthy response.

> *I have seen this strategy mentioned in the CAPS document, but I was not sure of it, I avoided it and stuck to the long method … I was afraid of confusing the learners. But with the long method (traditional algorithm) learners had a problem with carrying over. They can group numbers now according to their families quite good. That game…(silence); then shouted "he ke" (in vernacular) using hands and foot to snap for ones, tap for tens, clap for hundreds and stomp for thousands. My learners no longer struggle with place value. I just use these gestures and they know they must group accordingly. Even when adding six to nine digits they associate these gestures with grouping according to number families (CFA1, interview, March 2018).*

Club A Facilitator Two had this to say about place value:

> *learners usually make a mess when they are breaking down and building up numbers and that frustrated me since I never knew how to help them. After using click, tap, clap with hands and stamp with foot they now have no challenges with number and place values. This game improved discipline too in my class. They know when we play it they must be quiet, listen attentively take out their pen and paper to give out the number. I also use this game in class for the mental mathematics. I was always not sure what to do for the ten minutes prescribed in the CAPS for mental mathematics. I use all these club games not only in the clubs even in class. Although I was asked not to because of the study, but they tempt me (CFA2, March 2018).*

Club D Facilitator One agreed that decomposition of numbers according to place value was difficult to teach "…but after I had learnt the snap, clap, tap and stomp game from the PfP Programme and did it in the clubs my learners are no longer struggling with number families *(CFD1, February 2018)*

When asked whether these club strategies and activities mentioned were the only ones that influenced learner's shifts, Club C Facilitator One stated that the number line resonated well with her. "I knew of it and I normally use it in class for showing learners counting numbers forward and backwards. I have

never used it as a strategy for addition and subtraction. The learners love it and it has improved their subtraction. You can see that in the second test" *(CFC1, January 2018).*

Doubling strategy as a way of learning tables was mentioned by four of the facilitators. In response they noted that usually learners struggle with multiplication tables and using such a strategy improved learners' fluency in multiplication.

> *I like the arrays for multiplication and salute captain for addition and subtraction. That game you put the cards down like this (showing a horse shoe by hand) then takeout cards that add to ten, helped them to count quick. Being in the club space helped me, it made most of my work of explaining to learners easy could see measurable improvement (CFD1, February 2018).*

In drawing this theme to a close, I include some other comments from the teachers that talk to shifts in learners' procedural fluency and number sense.

> *Every school must have clubs, kids can benefit so fruitful (CFC1, January 2018)*

> *Giving more homework and those extra two hours improved the learner performance (CFC1, January 2018)*

4.3 Concluding remarks

In this chapter, I have presented, summarised and analysed the results from the learners' four operations assessments in terms of i) scores and percentage changes, changes in methods used to answer questions and ii) provided detailed learner vignettes of learners who made substantive progress and learners who did not. I have also presented data from the teachers' post club questionnaires and ono-to-one interviews indicating various themes that emerged.

In the next chapter I will use the data presented and analysed here to further discuss how the research questions for this study have been answered.

CHAPTER FIVE: CONCLUSION

5.1 Introduction

In the previous chapter I firstly presented and analysed the findings that relate to the pre- and post-baseline assessments results looking at the mathematical progression displayed by club learners in the SANC project's four operations (see instrument in Appendix 2). Secondly, I provided extracts of data from the teachers' semi structured interviews and questionnaires and summarised them according to various themes.

In this chapter, I summarise the data findings in the previous chapter in relation to the research questions for the study. Then look at it in the context of my broader research aim.

The research questions were:

1. What changes were evident in learners' number sense and procedural fluency through club participation?
2. What are teachers' experiences of learners' changing number sense and procedural fluency as a result of participating in the clubs?
3. What are teachers' experiences of working with learners in the club space?

5.2 Response to Research Question One

What changes were evident in learners' number sense and procedural fluency through club participation?

I address this research question in three parts. First, I will review what progress (if any) the club learners have made using the same structure as in Chapter Four in terms of club learners' scores, methods used by the club learners and detailed learner vignettes.

I intend to show how the scores; methods and vignettes intertwine in answering research question one as illustrated in Figure 20 below.

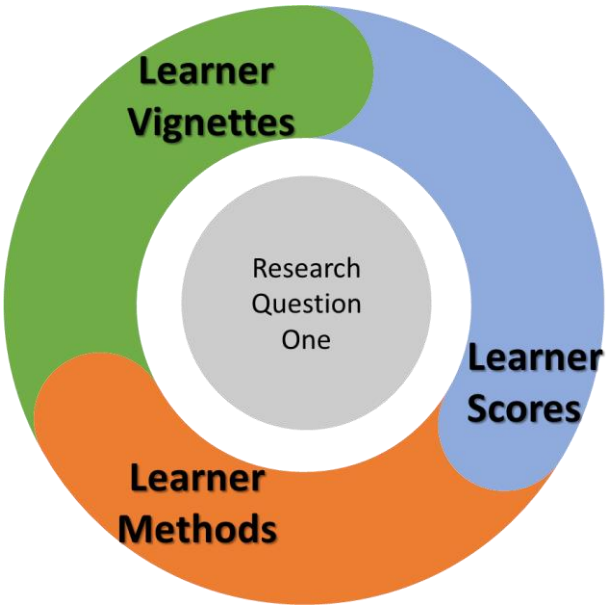


Figure 20: Interconnected data relating to research question one

5.2.1 Learner scores

The learner findings in Section 1.1 of Chapter Four summarised the club learners' pre and post assessments' scores and showed positive progress with the overall average percentage point change of 25. This means that the learners scores have improved by an average of five or more questions out of the 20 in the post-assessment than the pre-assessment.

In addition, there is a pleasing change across all four operations with the biggest change in multiplication (27%). If you look at individual clubs, there are variations in terms of average overall change. All club sites have shown positive progress: with club A (43%) showing the biggest progress followed by club B (39%), then E (22%), then C (10%) D (9%) showing the smallest gains. This differential change is expected as the clubs were run by different club facilitators, which I will discuss further later.

Although I do not have the records of the time all 60 of the club learners who took to complete both assessments, I do have that of the sampled learners in section 1.3 of Chapter 3 (see tables 9, 10 and 11). I note that those learners spent less time on the post-assessments (between 8 to 15 minutes less) than on the pre-assessments. One may argue that this may be due to the fact that it was not for the first time that they wrote the assessment. However, looking at the progress learners made on the assessments and the few procedural steps they showed on their computational strategies, I suggest that the improvement in their procedural fluency had an impact on the time it took to complete the post- assessment.

Remember that these learners were selected from the bottom (Level one) achievers of each Grade 6 class, learners that attained less than 40%. All of the changes presented show that there is quite substantive change in fluency in the time spent participating mathematics clubs.

As discussed in Chapter 2 Kilpatrick et. al (2001) define fluency as the ability to solve mathematical problems without referring to tables, calculators and other aids, using efficient ways to compute (add, subtract, multiply and divide mentally and on paper) and understanding when it is appropriate to use procedures or not. Meaning that, considering procedural fluency as the skill of carrying out procedures flexibly, accurately, efficiently and appropriately (Kilpatrick et al., 2001).

I argue that the data presented in the previous chapter suggests that within the 15 weeks of participating in the clubs, learners at the bottom of class could now attempt some advanced maths problems and answer more quickly and correctly. I take this to mean that their fluency was beginning to develop because they were working faster and more accurately.

For the purpose of this study, procedural fluency includes not only fluency but flexibility with numbers as well. From this perspective, the score-based data shows that there has been progress in learner fluency. These scores however do not tell us about the nature of learners' flexibility or number sense. For this I now turn to looking at the progress in learner methods to summarise the changes in flexibility and number sense.

5.2.2 Learner Methods

Table 10 in Chapter 4 shows that the overall averages show an increase in *no shown workings* (+26) and the use of *tally* methods has gone down by 6.2 on average. The biggest change is in the use of *non-tally* methods with an average increase of +41.6 responses.

Focussing on the increase of 26 correct responses for no shown workings. I assume that when learners show no workings in computing 2-digit by 2-digit problems in grade six, they are fluent enough to be working these out mentally (note, that the teachers did not record any occurrences of learners using their fingers). For non-tally methods, the increase of 41.6 responses and decrease in tally methods indicate that learners were opting to use other methods rather than tallies to answer assessment items.

Kilpatrick et al. (2001)'s definition of fluency also includes rapid recall of facts. Thus, if learners are doing more without workings, it seems that they must be recalling something from what they already

know – hopefully their basic addition and multiplication facts. So, they are spending less time working out basic facts and actually using them instead.

The learner vignettes in Chapter 4 support the above method changes. Remember, at the beginning of the PfP Programme intervention, the pre-assessments revealed that the vast majority of learners only had access to two strategies: namely tallies and traditional algorithms. Tallies are constrained methods with respect to the spectra illustrated in Figure Three of Chapter 2. Learners by this grade should have moved from counting all to at least semi fluent, flexible and fluent methods. Even such methods are not appropriate for the number ranges used in the assessments, as according to the Intermediate Phase CAPS, Grade 6 learners are supposed to compute at least up to 6-digits.

It was quite pleasing when the club facilitators attested how learners have improved in procedural fluency and number sense because of participation in the clubs. They mentioned in some way or another that the fluency and flexibility of the learners have improved.

If I may refer you back to Chapter 2, where it was noted that Grade 6 learners are said to be stuck using concrete methods such as tally marks to answer problems SANC,2016)). Research shows that Grade 6 learners will generally try to solve problems using an algorithm (a standard technique they are taught at school). If this approach fails, they tend to fall back on using their fingers or tally marks. Star (2005) explains that this scenario can occur when procedural knowledge is superficial; learners will have no option but to use a standard technique (the traditional algorithm in this case) to solve a problem. Learners with deeper knowledge will have more choices in the range of strategies they can choose from and use.

Therefore, if teachers observed club learners having a choice and using different strategies, they were also able to answer quicker using the strategies they had learnt form the clubs; then teachers would have experienced learners progressing in their fluency, flexibility and coupled with their number sense.

With all the inference cited above showing positive progression evident within the workings, scores of club learners, shifts in spectra levels and those indicated in learners' vignettes, I am tempted to say that the club learners' number sense and procedural fluency have shifted, such that their methods have shifted to perhaps more flexible options.

5.2.3 Detailed learner vignettes

In this section I refer to learner vignettes from Section 1.3 of the previous chapter in order to explore shifts and progress made by the learners in procedural fluency and number sense more deeply. I extrapolate specifically on the progress made by learners in displaying such shifts.

As we can recall from Figure 12 in Chapter 4 that in the pre-assessment, learner A1 lacked number sense as she was unable to subtract 2 from 8 correctly. Learner A1 used constrained methods to find a solution in the pre- assessment responses. In the post- assessment responses (refer to Figure 13), the learner used a number line representation to correctly answer the two more difficult subtraction questions with a bigger number range. Thus, we can safely say that the learner moved from a constrained approach in pre-assessment to somewhere between a semi-fluent and flexibly, fluent position in the post-assessment responses. In the analysis of the post-assessment responses, the learner showed knowledge of some basic facts (showing fluency) and also the use of the use the number line strategy for working out the more difficult items (exhibiting some number sense and flexibility).

Learner A6 unsuccessfully attempted item 3.5 inthe pre-assessment test using both the tally method and the traditional algorithm to work out 120 multiplied by 15. The learner chose to use the grid method in the post assessment test to successfully solve the problem. The variety of responses used by this learner likely indicates improved accuracy, deeper number sense particularly in place value with larger number range and fluency in known multiplication facts of 10 and improved flexibility, instead of relying on the vertical column method (traditional algorithm).

Learner B27 used a similar method as A6 in responding to item 3.4 in the pre-assessment test. In the post-assessment test B27 chose to use repeated addition, which showed some level of understanding and perhaps developing number sense whereas the methods used in the pre- assessment test displayed that the learner had no sense of numbers at all.

Finally, the same learner (B27) attempted item 4.4 using a vertical column method incorrectly in the pre-assessment test. In the post- assessment test, she drew 75 circles and counted these off in groups of three to correctly answer the question. Even though she arrived at a correct response using this method, in terms of my analytic frame, I argue that this is not a fluent method for dividing 75 by 3. In Grade 6, learners are expected to use known division facts to answer questions like this. Alternatively, a learner with deeper number sense of division may use the inverse of known multiplication facts to get to the solution.

For learner B27, the responses to all the multiplication and division items in the pre-assessment test reveal that the learner knew some basic facts which suggests some level of fluency. However, the approaches used to answer the more difficult items indicated a lack of sense making and fluency. So, the learner could be said to be at a constrained level overall, for this grade.

In the post-assessment test, the knowledge of some facts remains, interspersed with some semi-fluent methods for the more difficult items. One could place the learner at the semi-fluent position on the spectrum as both the multiplication and division methods used do show an emergence of sense making. This data seems to align with Kilpatrick et al.'s (2001) definition of procedural fluency.

As I mentioned in Chapter 3, at the teachers' request, we had additional unplanned teacher development workshops to strengthen the teacher's knowledge and pedagogy especially with regard to number sense, fluency development and the use of different procedures such as the grid method for multiplication and number line for addition and subtraction.

Star (2005) says that when a learner has more procedural knowledge, they have more flexibility, more choices for the ways they approach answering a question. This seems to the case here. Once learners were shown different methods by the facilitators, they tried to use them in the post-assessment test, often successfully. Thus, I suggest that the additional initiatives by the club facilitators and the extra teacher workshops likely had some effect on learners' progress through the 15 weeks.

5.3 Response to Research Question Two

What are teachers' experiences of learners changing number sense and procedural fluency as a result of participating in the Clubs?

The data findings from the post club teacher questionnaire in Chapter 2 were themed into four themes namely learning environment, learning approach, learning participation and attitudes and changes in learners' procedural fluency and number sense.

I will do the same here in exploring this research question. In this section, I draw on the data from the 'learners' procedural fluency and number sense' theme and review the other three themes under research question 3.

The teachers noted that the club learners answered more quickly, counted and computed faster. They attributed these shifts to the games since they believed that such games helped develop the learners'

number sense, fluency and flexibility. They mentioned games such as "fizz pop" for number bonds, doubles, halves etc. and "click clap snap stomp" for place value and number family reinforcement. Hence, the learners were able to retrieve number facts from memory and no longer depended on using their fingers and tallies.

Teaches also noted that the club learners were now not only keen to attempt work given to them, they answered without being probed, they also showed renewed efforts in doing their work, and they did their homework. They have developed love for the subject. Teachers also, claim that one can see from their workings that their work was not copied from the way they had attempted the activity. The Clubs have made them ready for grade seven.

As I was analysing the data, I realised its richness and believe this richness stems from the unintended or adapted version of the PfP Programme. Recall as I explained in Chapter 2, due to teacher requests, I ran extra teacher capacitation workshops that were not part of the original PfP 15-week Programme. Four out of the five club sites ran club sessions twice a week instead of once a week, as in the initial SANC project club design. Two of the club facilitators introduced the club buddie's system. All such extra efforts and initiatives seemingly worked well and contributed to the shifts in number sense, procedural fluency and unintended productive dispositions developed in the club members through c participation with the 15 weeks. Not only did these learners gained a lot by being part of the clubs but by also being the club buddies and club facilitators as well.

5.4 Response to Research Question Three

What are teachers' experiences of working with learners in the club space?

In this section, I draw on the three remaining themes from the teachers' interviews.

5.4.1 Learning environment

All the club facilitators in one way or another stated how they felt to be in the learning environment of the club space and what it meant to them. They also noted that it was the first time they were exposed to such an environment. They used phrases like being 'empowered', 'feeling good' and felt honoured to express how they felt as club facilitators.

Club facilitator B1 claimed that she learnt to make questions fun and give clear instructions and make learners see joy and fun in mathematics. The co-facilitator from the same club mentioned that they also

learnt a lot of new strategies that are mentioned in the IP CAPS that she never attempted to use as she did not know how to. Recall from Chapter 3, some of the facilitators decided to augment the club design by introducing club buddies, use extra time and also requested more information on how to use these strategies and understand number sense in order to meet the demands of the club.

> *I felt empowered and learnt a lot of strategies mentioned in the CAPS that I could use since I at first didn't know how for example, the use of the number line and the grid methods (CFB2, January 2108)*

Club Facilitator B1 claimed that the club environment enabled change since the atmosphere was relaxed, informal and learners worked at ease. She also claimed that Club members enjoyed being in that environment since they had fun and learnt through play.

Recall from Chapter 2, Burns (2007) suggested that learners who have experienced failure and lack of confidence and who lack and have gaps in foundational mathematics, should be provided with more time and attention in an environment that is different than that of the normal classroom. Consequently, I suggest that the teachers' experiences as club facilitators had a positive effect on the club learners and could account for the shifts in scores and improved methods detailed in the first section of this chapter. I am also tempted to say that the club environment not only impacted the learners, but the facilitators as well based on their interview responses.

These mathematics clubs are intentionally designed in such a manner that learners have an extra hour and more time at home (using the take home books) to interact with mathematics in a fun way. The environment of the club space is completely different to that of the normal classroom with the aim of developing individual learner mathematical proficiency, number sense and more participatory practices in a social club context (Stott, 2016).

The fact that there were only twelve learners in a club contributed to the development of procedural fluency and number sense in learners since some of the facilitators claim that they had forged better relations with the learners and could pay individual attention to the them since the club size was small.

5.4.2 Learning approach

All participants described how they perceived the way the learners learn in the Clubs. They also articulated how the game-based activities provoked learner thinking, the impact of working in a small group and in pairs and the role played by the pre-assessment test for them as teachers to see the level of

fluency (in the terms of the spectra) the learners were in with respect to operations. Club Facilitator C1 claimed it was "eye opening" to experience the impact of games and club activities on learners. Club Facilitator E1 mentioned that learning through play in clubs, while a bit chaotic at first, later became an organised and fun chaos.

Club Facilitator C1 and Club Facilitator E1 mentioned that there was more space in the club environment to alleviate pressure for both the learners and the facilitator. They noted that since they were playing, the Programme was not intense as in the classroom. Furthermore, activities were structured such that they gave a smooth transition for learners such that they did not feel that the task was too different or on a higher level compared to the one they did before.

Recall, this study was built on the club design conceptualised by the SANC Project where it is believed that learners can learn through playing carefully designed dice and cards games collaboratively with peers and the club facilitator. The activities offered are designed to promote progression from using concrete methods to more efficient ones in a more actively, engaging and informal environment (South African Numeracy Chair, 2016).

In Chapter 2, I referred to Venkat and Bowie (2017) who stated that since children enjoy playing games, well thought out games can be useful tools to make a class fun while engaging the learners in mathematics. Oldfield (1991), in agreement with Bowie and Venkat maintains that games give enjoyment and provide a way of eliminating drudgery.

For example, dice games have been used to develop children's counting skills and have produced significant improvement in enumeration and the construction of collections (Hughes, 1986; McConkey & McEvoy, 1986). In summary, the teachers' observations about the relaxed atmosphere in the club space, small sized groups, learning through play with co-members may have enabled the shifts in procedural fluency and number sense in club learners.

5.4.3 Learning participation and attitudes

Enjoyment, relaxed, having fun, and interacting more (i.e. active participation) were some of the phrases used by the club facilitators when asked how they found working with the learners in the club environment. They articulated how the club space impacted their attitudes in one way or the other mentioning that there was a difference in learners' attitude not only in the club space but also in the class. When learners were having fun they were at ease, they interacted more freely and responded to questions (CFA1, January 2018). Some of the facilitators elaborated on learners' dispositions stating that learners

no longer feared mathematics or bunked classes. Club Facilitator D2 observed that "their dignity is back" (CFD2, February 2018). Learners were more confident and no longer uptight, withdrawn, timid or passive (CFC1, February 2018).

In Chapter 2, I discussed, Vygotsky's (1978) perspective on the role of social environment and context in the cognitive development of a child. From this perspective learning and development appears first on the social level and then on the individual level. The club facilitators noted that the development of fluency, flexibility and numbers sense in the club learners was supported when the learners were interacting socially with their peers, without even realising that they were learning.

This was an unexpected finding for this study. I did not anticipate that the club learners' dispositions and attitudes would have shifted. Although the clubs are intentionally designed to take into account individual and social development as indicated in Chapter 2, I was unprepared for how much positive feedback the teachers gave me about this aspect.

5.5 Concluding remarks

In concluding this section, the following diagram in Figure 21 summarises the themes that emerged from the data I collected from the teacher through questionnaires and interviews. It represents how all the themes connect together to reveal how the majority of learners made progress within the clubs.

Figure 21: Summary of four themes derived from the teacher data

The overarching aim of this research was to investigate whether the club could be a productive learning space for learners when clubs are run by their teachers. I suggest that based on my findings these clubs, run by teachers and not members of the SANC project team or outside volunteer facilitators, were a productive space for developing learners' procedural fluency and number sense. This is evident in the progress and shifts in procedural fluency and number sense shown by the data findings. I note with interest that 57 out of the 60 club learners in the PfP Programme of this study improved sufficiently to be promoted to grade seven at the end of 2016. Recall that the learners chosen for these clubs were in the low performing pool. Teachers indicated that they bunked classes, had low morale and low or no confidence at all. It is compulsory in South Africa that learners pass mathematics with level three in order to progress to the next grade.

While all five clubs showed learner progress, it is worth nothing that some clubs were more productive (in terms of improved scores and learners' methods) than others. This is to be expected as the clubs were run by different club facilitators with different mathematical knowledge and pedagogical approaches. Also, other contextual factors would differ slightly from club to club. The South African Intermediate Phase CAPS works on the assumption that teachers know all the methods and the activities to be done for mental maths prescribed in the curriculum. However, being part of the club Programme has raised the issue of this gap in teachers' knowledge and pedagogy. The Programme has helped me as a District Official to realise the importance of my role in working towards strengthening teacher knowledge and closing such gaps.

5.6 A reflection on my own learning

The commitment and passion displayed by the teachers in this intervention, their eagerness to try something different and new to improve the teaching and learning in their mathematics classrooms was incredible. As I noted earlier, these teachers showed interest and volunteered to be part of this intervention Programme when I introduced it to them. These are the ever willing and lead teachers in our District and I am incredibly privileged to have had the opportunity to work with them and learn from them both as a researcher and a District official.

Therefore, being part of this Programme and process has made me see that it is possible to make a difference in both teachers and learners' mathematics by using the afterschool mathematics Clubs as an intervention Programme to improve not only learners' procedural fluency and number sense, but learner results as well.

Not only did this Programme make an impact on the club members and facilitators; I have also grown, learnt a lot and was groomed by this journey. It is my wish that in the future more than 60 learners, the unintended 24 club buddies and nine teachers will benefit from this intervention.

In my future work, I hope to support the spread of this club intervention to other Districts in our Province since I believe it will be beneficial. Our matric results for mathematics keep on reminding us annually; that we need to strengthen the foundations in the GET band mathematics and do things differently for a complete turnaround. The crisis in mathematics education is widely acknowledged as noted earlier despite South Africa's relative wealth and investment in education. Also, the DBE: ANA assessments (2011-2014) results in Grade 4 with the average of 35% and that of Grade 9 of 13% have shown the need to address gaps.

I carry and use the rich, lifelong knowledge I have gained from this Programme. I promote the club games and activities in the intervention Programmes initiated by ECPDE and DBE that am responsible for. I also had an opportunity to share such knowledge and skills with the other mathematics Curriculum/Subject Advisors I work with in the Eastern Cape Province.

I mentioned earlier regarding my professional growth for the past three years as a result of being part of the SANC Project from the PfP Programme's perspective. It does not end there: this research study has provided me with opportunities to engage in different forums such as the Annual Community of Practice (COP) forum hosted by the DBE in both 2017 and 2018. Additionally, I was part of the team that initiated formative assessment test lets at a week-long EMpekweni workshop in 2016. My role there was to provide a District perspective and first-hand classroom experience as shared by teachers I work with.

Professionally, I have grown out of such exposure and interactions. I attended and presented at conferences namely the AMESA Regional Conference as a plenary speaker in 2017 at Sterkspruit. I attended the AMESA National Congress in Port Elizabeth in 2017, the SAARMSTE conferences in Bloemfontein in 2017 and Botswana in 2018.

As I have shared my experiences and research findings in these other fora (such as EC Mathematics ISP SAs INDABA in 2018 and FP SAs and Mental Maths Quiz in 2017), it has led to much interest in clubs by other Districts in the EC Province. I have been offered various platforms to present and run workshops on how to develop Clubs with mathematics teachers in Port Elizabeth, the broader Eastern Cape and beyond. I have also attended additional club workshops run by the SANC project team at NGOs such as Masifunde Education Trust.

Having such powerful opportunities to try out and test possible solutions to the challenges in South Africa's mathematics classroom with the support of the SANC Project and PfP Programme and the relations established with the SANC Project have empowered me to be a better supporter and advisor to the 389 mathematics teachers I work with.

5.7 Avenues for further research

For further research, one could use the clubs to explore possible gains in the development of other mathematical proficiency strands such as conceptual understanding and productive disposition in learners. That would be vital for our country at this point since such a study would also contribute and assist the practitioners in mathematics education towards implementing the new Mathematics Teaching and Learning Framework for South Africa: Teaching Mathematics for understanding (TMU) developed by the DBE and currently being implemented (piloted in the Eastern Cape, KwaZulu-Natal and Limpopo).

Additionally, since my research pointed to powerful shifts in teachers' attitudes, learners' dispositions and methods of teaching mathematics, further research could also explore this aspect in more detail.

5.8 Recommendations for DBE

I suggest the alignment of the PfP programme be included in the Calendar of the Province and Districts not as an add-on, going forward. Also, such programme be aligned with the TMU Pilot as the mathematics clubs will surely enhance the research path teachers and learners have already started and made solid gains on. The teachers should receive copies of the Framework and be made aware of the direction in which the teaching of mathematics in the country is moving towards- conceptual understanding as one of the five strands of mathematical proficiency including the procedural fluency club facilitators have already embarked and succeeded on.

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Appendix One – Permission to undertake research

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)40 608 4773/4035/4537 • Fax: +27 (0)40 608 4574 • Website: www.ecdoe.gov.za

Enquiries: NY Kanjana Email: nykanjana@live.co.za Date: 26 January 2017

Ms. Noluntu Baart

66 Hunters Close

Parsonvlei

Port Elizabeth

6025

Dear Ms. Baart

PERMISSION TO UNDERTAKE A MASTERS THESIS: INVESTIGATING GRADE 6 LEARNERS CHANGING MATHEMATICAL PROCEDURAL FLUENCY AND LEARNING DISPOSITIONS THROUGH PARTICIPATION IN AFTER SCHOOL MATHEMATICS CLUBS

1. Thank you for your application to conduct research.
2. Your application to conduct the abovementioned research in five Primary Schools under the jurisdiction of Uitenhage District of the Eastern Cape Department of Education (ECDoE) is hereby approved based on the following conditions:
    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 Cluster and District Directors before any research is undertaken at any institutions within that particular district;
    d. you will make all the arrangements concerning your research;
    e. the research may not be conducted during official contact time;
    f. should you wish to extend the period of research after approval has been granted, an application to do this must be directed to Chief Director: Strategic Management Monitoring and Evaluation;

g. your research will be limited to those institutions for which approval has been granted, should changes be effected written permission must be obtained from the Chief Director: Strategic Management Monitoring and Evaluation;

h. 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.

i. you present the findings to the Research Committee and/or Senior Management of the Department when and/or where necessary.

j. you are requested to provide the above to the Chief Director: Strategic Management Monitoring and Evaluation upon completion of your research.

k. you comply with all the requirements as completed in the Terms and Conditions to conduct Research in the ECDoE 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 Chief Director: Strategic Management Monitoring and Evaluation.

3. The Department reserves a right to withdraw the permission should there not be compliance to the approval letter and contract signed in the Terms and Conditions to conduct Research in the ECDoE.

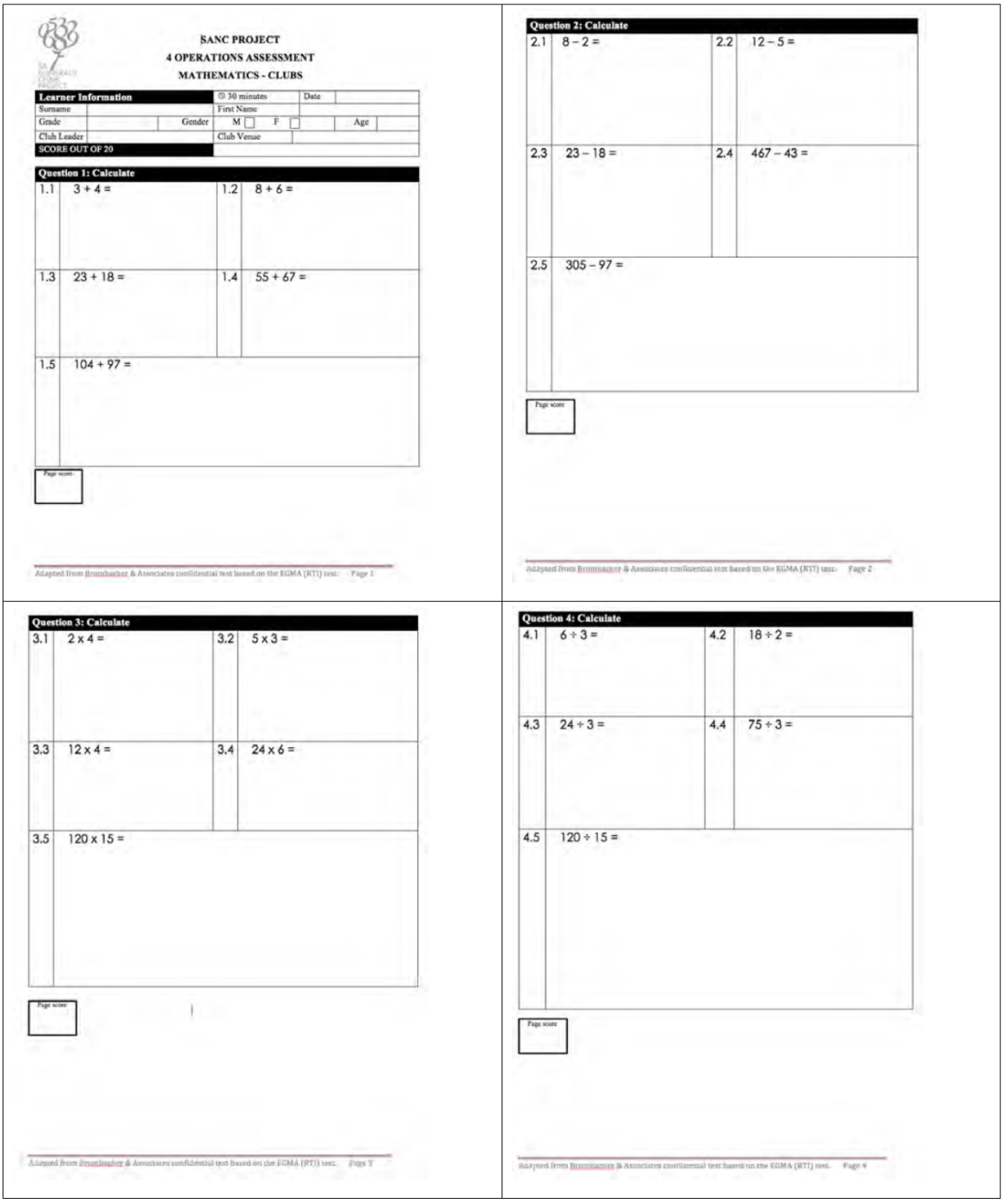
4. The Department will publish the completed Research on its website.

5. The Department wishes you well in your undertaking. You can contact the Director, Ms. NY Kanjana on the numbers indicated in the letterhead or email nykanjana@live.co.za should you need any assistance.

NY KANJANA
DIRECTOR: STRATEGIC PLANNING POLICY RESEARCH & SECRETARIAT SERVICES

FOR SUPERINTENDENT-GENERAL: EDUCATION

Appendix Two – 4 operations assessment



SANC PROJECT
4 OPERATIONS ASSESSMENT
MATHEMATICS - CLUBS

Learner Information			30 minutes	Date	
Surname			First Name		
Grade		Gender	M ☐ F ☐	Age	
Club Leader			Club Venue		
SCORE OUT OF 20					

Question 1: Calculate

1.1	3 + 4 =	1.2	8 + 6 =
1.3	23 + 18 =	1.4	55 + 67 =
1.5	104 + 97 =		

Page score

Adapted from Bromhacher & Associates confidential test based on the EGMA (RTI) test. Page 1

Question 2: Calculate

2.1	8 – 2 =	2.2	12 – 5 =
2.3	23 – 18 =	2.4	467 – 43 =
2.5	305 – 97 =		

Page score

Adapted from Bromhacher & Associates confidential test based on the EGMA (RTI) test. Page 2

Question 3: Calculate

3.1	2 x 4 =	3.2	5 x 3 =
3.3	12 x 4 =	3.4	24 x 6 =
3.5	120 x 15 =		

Page score

Adapted from Bromhacher & Associates confidential test based on the EGMA (RTI) test. Page 3

Question 4: Calculate

4.1	6 ÷ 3 =	4.2	18 ÷ 2 =
4.3	24 ÷ 3 =	4.4	75 ÷ 3 =
4.5	120 ÷ 15 =		

Page score

Adapted from Bromhacher & Associates confidential test based on the EGMA (RTI) test. Page 4

Appendix Three – Assessment Profile

Addition and Subtraction

Addition and subtraction assessment											
Club name			No. of learners		Note 1		Notes				
Date of assessment			Grade								
Spectrum											
		Constrained methods		*Less constrained*		*Semi fluent methods*		*Flexible fluency*			
		Inefficient (I)		*Somewhere in between (IE)*				*Efficient (E)*			
		Use of fingers, tally marks, circles, drawings of any kind		Breaking down into place value, using some kind of expanded notation		Another strategy such as splitting, working with a friendly number		Use of known addition and subtraction facts, appropriate use of algorithms for 2 and 3 digit problems			
Assessment Profile											
Questions	Answers	Constrained methods		Less constrained methods		Semi fluent methods		Flexible fluency		Overall	
		Wrong answer	Correct answer	Wrong answer	Correct answer	Wrong answer	Correct answer	Wrong answer	Correct answer	No. of CORRECT answers	Predominant strategy used (I, IE or E)
Addition Questions											
A. Q1											
3 + 4	7	||||| ||||| ||	||||| |||||	Note 2					|||	||||| ||||| |||||	31	I
Totals		12	16					3	15	Note 4	Note 5
A. Q2			Note 3								
8 + 6	14										
Totals											
A. Q3											
23 + 18	41										
Totals											
A. Q4											
55 + 67	122										
Totals											
A. Q5											
104 + 97	201										
Totals											
Subtraction Questions											
S. Q1											
8 - 2	6										
Totals											
S. Q2											
12 - 5	7										
Totals											
S. Q3											
23 - 18	5										
Totals											
S. Q4											
467 - 43	424										
Totals											
S. Q5											
305 - 97	208										
Totals											
NOTE:	Learners using fingers to calculate answers										
	Observe learners as they are writing the assessment. Note learner intials on a blank 4 operations script under the relevant question number										
	Then allocate a tally mark to the Constrained Methods column for that learner										

Multiplication and division assessment										
Club name			No. of learners		Note 1		Notes			
Date of assessment			Grade							

Spectrum				
	Constrained methods	*Less constrained*	*Semi fluent methods*	*Flexible fluency*
	Inefficient (I)	*Somewhere in between (IE)*		*Efficient (E)*
	Use of fingers, tally marks, circles, drawings of any kind	Skip counting, repeated addition	Arrays, breaking down into expanded notation	Use of known multiplication and division facts, appropriate use of algorithms for 2 and 3 digit problems

Assessment Profile

Questions	Answers	Constrained methods		Less constrained methods		Semi fluent methods		Flexible fluency		Overall	
		Wrong answer	Correct answer	Wrong answer	Correct answer	Wrong answer	Correct answer	Wrong answer	Correct answer	No. of correct answers	Predominant strategy used (I, IE or E)
Multiplication Questions											
M. Q1											
2 x 4	8	5 + 5 + 2	5 + 5 + 5 + 1 Note 2					3	5 + 5 + 5	31	I
Totals		12	16 Note 3					3	15	Note 4	Note 5
M. Q2											
5 x 3	15										
Totals											
M. Q3											
12 x 4	48										
Totals											
M. Q4											
24 x 6	144										
Totals											
M. Q5											
120 x 15	1800										
Totals											
Division Questions											
D. Q1											
6 ÷ 3	2										
Totals											
D. Q2											
18 ÷ 2	9										
Totals											
D. Q3											
24 ÷ 3	8										
Totals											
D. Q4											
75 ÷ 3	25										
Totals											
D. Q5											
120 ÷ 15	8										
Totals											

NOTE:	Learners using fingers to calculate answers
	Observe learners as they are writing the assessment. Note learner intials on a blank 4 operations script under the relevant question number
	Then allocate a tally mark to the Constrained Methods column for that learner

Appendix Four – Sample Club Session Planning Sheets for Intermediate Phase

Session Six

IP	Maths Club Whole Session Planning Sheet	**Session Six**
Purpose of the session / object of learning	Pyramid sums brings the focus back to the relationship between addition and subtraction.	

What resources / manipulatives will you need?	**Home sharing/ Pay It Forward task**
• FLIP OUT: Packs of cards / sections of packs for each learner, scrap paper and pencils • PYRAMID SUMS: activity sheets inside plastic sleeves, kokis, cloth	Ask learners to play FLIP OUT at home with their own pack of cards
Organisational requirements	**Your approach to running the session**
• FLIP OUT: pair work • PYRAMID SUMS: individual work	Demonstrate one or two Pyramid sums on the board. Allow learners to work with Pyramid sums from bottom to top first. Then introduce how you work backwards with a number at top and how this brings in counting back and counting down to strategies.

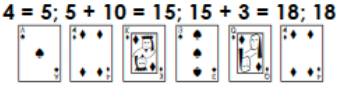
Mental warmup: HOW MANY TO MAKE 50 – 5 minutes

- Practice numbers that add to 50. Say "I will say a number and you must say how many more to make 50"
- The game starts with leader saying "FIZZ", club responds with "POP"
- Say the number and club responds. E.g. "10" and club responds with "40"
- Start with decade numbers
- Then move onto numbers that have 5 in the units place e.g. 25, 35 etc
- If learners are coping, try other numbers.
- If they struggle, remind them of the 'friends of 10'. So if you say 37, encourage them to think of the friend for 7, which is 3, so answer is 23.

Game: FLIP OUT – 15 minutes

Play with a partner or a group Of 3 or 4.
Use 1 deck of cards per player (or equal parts of a deck each), scrap paper & pencil
Picture cards = 10, Ace = 1

- Each player shuffles his/her deck and lays it **FACE DOWN**
- A timer calls out: "Go!" and times 1 minute.
- Each player flips over one card at a time and calculates a running total of the values on the cards.
- After one minute the person keeping time shouts "Stop!"
- Players write down their total
  e.g. 32 for this set of cards:
  1 + 4 = 5; 5 + 10 = 15; 15 + 3 = 18; 18 + 10 = 28; 28 + 4 = 32



- Players check each others totals
- The winner is the one with the highest total. You cannot win if your total is wrong.

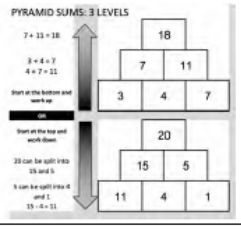
PFP (EXTENSION) AND VARIATIONS

- You can change the time depending on the players' abilities
- Make the picture cards: King = 13, Queen = 12, Jack = 11. A joker can be used to equal 20 or 50.

Activity: PYRAMID SUMS - 30 to 40 minutes

Object of learning: This activity provides the learners with lots of practice in adding and subtracting. When a number is placed at the top of the pyramid, they must understand how to use addition to help work out subtraction. Start by giving learners the 3 level pyramids and use various methods to provide numbers for them to add up, starting with single digit numbers at the bottom.

When they are more fluent, move onto the 4 level pyramids and use a mixture of 1 and 2-digit numbers as this will extend the number range.



IP	Maths Club Whole Session Planning Sheet	**Session Thirteen**
Purpose of the session / object of learning	The focus here is on introducing learners to the grid method of multiplication	

What resources / manipulatives will you need?	**Home sharing/ Pay It Forward task**
• **NUMBER SENSE:** white/blackboard or flipchart • **GRID METHOD:** Copies of the grids in plastic sleeves, kokis and cleaning cloth	Homework books, particularly Multiplication and Division book to practise the grid method.
Organisational requirements	**Your approach to running the session**
• **NUMBER SENSE:** individual, then whole group • **GRID METHOD:** Learners work alone	Learners will need a great deal of practice with using the grid method to multiply, starting with 2-digit by 1-digit problems, working up to 3-digit by 3-digit problems. Master copies of worksheets for practicing this method can be found on the SANC Project website[1].

Number sense: COMBINATIONS THAT MAKE 90 USING + and x – 20 minutes

Put these numbers up on the board / flipchart for the learners

Learners must look for combinations of numbers that **make 90 using + and x**
Example: 15 + 45 + 20 + 10

16	20	18	2
43	10	45	4
24	15	27	5

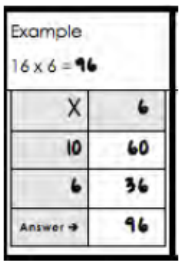
After 10 minutes, gather contributions from learners and write them on the board. Try not to judge if right or wrong – let the club do that.

Activity: GRID METHOD – 40 minutes

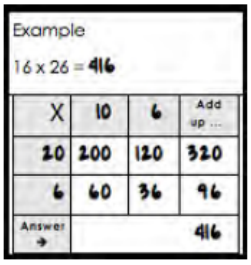
Introduce the GRID METHOD of multiplication

Using the information on page 8, introduce the learners to the grid method. If your learners already know how to use the long multiplication algorithm, make the connections between the grid method and the algorithm by noticing the numbers and using the array (grid) to see where these numbers arise from.

We suggest starting with 2-digit by 1-digit problems such as the one shown in the picture e.g. 16 x 6


Example
16 x 6 = 96

X	6
10	60
6	36
Answer →	96


Example
16 x 26 = 416

X	10	6	Add up ...
20	200	120	320
6	60	36	96
Answer →			416

Then allow the learners to practice on the activity sheet with these examples, or make up your own:
26 x 7
34 x 4
46 x 3
76 x 6

If learners are confident with these, you could introduce 2-digit by 2-digit examples, starting with the one shown e.g. 16 x 26. Allow them to practice with some of your examples on the activity sheet.

Appendix Five – Post club teacher questionnaire transcripts

Item 1: Can you describe how you felt as a facilitator in the club space?		
Respondents	**Response category**	**Responses**
CFA1[9]:	Relevant	*"I felt good because I change learner's attitude in maths"*
CFB1:	Relevant	*"It made me feel empowered and strengthened the training I received as a Maths teacher"*
CFC1:	Relevant	*"I felt relaxed at the beginning as time goes by I felt confident as the group number (referring to club size) could be easily manageable and give individual attention to the others (referring to club members)"*
CFD1:	Relevant	"*Very honoured to work with learners who encountered learning problems as someone who had remedial experience on how to deal with them I gained more idea to add on that I have which are more enjoyable to the learners and easy to understand.*
CFE1:	Relevant	"*I felt privileged and honoured! I felt that here is an opportunity for me to make a change in kid's life (In their Maths life)"*
Table 9a: club facilitators responses on item 1 of the post-club teacher questionnaire		

[9] CFA1 represents the first (1) club facilitator (CF) of club A. The similar notation has been used for Clubs B, C, D and E.

Item 2: Describe your experience of working with the supportive club ethos		
Respondents	**Response category**	**Responses**
CFA1:	Relevant	*"The strategies used in activities gave them a chance to think critically and work on their own without my interference and the learners enjoyed the maths games"*
CFB1:	No response	*None*
CFC1:	Less relevant	*"It was very fruitful. The new methods and approach that they can apply in your daily presentation and introduction of a new lesson in classroom situation"*
CFD1:	No response	*None*
CFE1:	Less relevant	*"To start with it really opened my eyes! To see and noticed that some kids really had no clue or have been neglected on how to do the basic. It excited me at the end to see them do better"*

Table 9b: Club facilitators' reflections on their experiences on working with club ethos

Item 3: What was your experience of working with **learners** in the club space compared to that of the classroom with respect to:

a. tracking changes in learners' progression over the 15-weeks, after doing the baseline assessment?

Respondents	Response category	Responses
CFA1:	Relevant	*With the club group, you use individual attention because they are few but its difficult in the classroom of 40+. Learners from the maths Clubs more active now and have improve exam marks in this term*
CFB1:	Relevant	*In the classroom base-line assessment is followed by simply following the syllabus, while in the club space challenges discovered during the base-line assessment form the "syllabus to be covered to help the learners understand Maths better.*
CFC1:	Relevant	*Some learners show significant progress changes can be seen in classroom performance. They also progressed in their daily school activities and tasks.*
CFD1:	Incomprehensible	*Club space – you deal with a small number of learners which makes it easier to attend to each an everyone, giving them individual attention.*
CFE1:	Relevant	*Assessments, body language, attitude and interaction with teacher and other pupils or learners*

Table 9c: club facilitators' responses on tracking learner progression

Item 3: What was your experience of working with **learners** in the club space compared to that of the classroom with respect to; -

b. the role of club activities and assessment tools in helping you gain sufficient insight into learners changing understanding of mathematical concepts?

Respondents	Response category	Responses
CFA1:	Relevant	*In the classroom I have limited time for Maths operations while in the Maths club space I focus on them until the results are achieved*

CFB1:	Relevant	*In the classroom base-line assessment is followed by simply following the syllabus, while in the club space challenges discovered during the base-line assessment form the "syllabus to be covered to help the learners understand Maths better.*
CFC1:	Relevant	*Yes. To teach mathematics does not mean you should only focus on the textbook but games also play a big role.*
CFD1:	Relevant	*All learner's needs are met, no one is left unattended. CLASSROOM: it is not easy to attend to all of them the numbers are big*
CFE1:	Relevant	*Yes! Definitely the different activities for adding and thinking was amazing.*

Table 9d: club facilitators' responses on item 3b on tracking learner progression

Item 3: What was your experience of working with **learners** in the club space compared to that of the classroom with respect to; -

c. what you learnt about how to extend learners during activities?

Respondents	Response category	Responses
CFA1:	Less relevant	*I've learnt that learners need to be free, when they are free they can express their thinking and can explain how they got the answers and knowledge of the concept*
CFB1:	No response	*None*
CFC:	Less relevant	*They enjoyed the activities and you must have control and give them enough time, so that they all understand and be able to explain the rule for the game or activity*
CFD1:	Less relevant	*In 4 basic operations learners enjoyed more (+; −; ×) more especially when using number bonds and friendly numbers. In division, they struggle a little bit with division especially with big numbers.*
CFE1:	Relevant	*Differentiation is vital. The games were simple and built up gradually. The tier of difficulty: the kids were lead-in, focused and challenged.*

Table 9e: club facilitators responses on item 3c of the post-club teacher questionnaire

Item 3: What was your experience of working with **learners** in the club space compared to that of the classroom with respect to; -

d. how you felt about learners working in groups and pairs?

Respondents	Response category	Responses
CFA1:	Relevant	*They help one another to find correct answers. They share information, skills and strategies learnt from the Clubs.*
CFB1:	Relevant	*In the maths classroom the groups are very generic whereas in the Maths club space the groups are target shooting.*
CFC1:	Relevant	*Group is easily manageable compared to class size. Grouping is very important for their own learning. They understand easy when they explain to one another.*
CFD1:	Relevant	*Small group: Its good because you give them all individual attention, help them where necessary also they get immediate feedback unlike working with a large number ending up not finishing marking and feedback is given immediately on the same day in Clubs*
CFE1:	Relevant	*Group work is a must for me in certain lessons, maths buddies, differed ways and ideas came forth (better math communication in class).*

Table 9f: club facilitators responses on item 3d of the post-club teacher questionnaire

Item 4: Is there any information you would like to share?		
Respondents	**Response category**	**Responses**
CFA1:	Relevant	*The maths Clubs has improve learners ability to calculate and improve their self confidence in maths. Maths Clubs have taken away the fear of Maths. They must spread*
CFB1:	Relevant	*Without having any intentional Programme to improve Maths skills in our learners and teachers we can't improve Maths results at any grade or level. Whoever discovered this Maths club Programme is the best.*
CFC1:	Relevant	*Mathematics club Programme is very good. I think it should be extended to all learners in the grade because of its enjoyment and easy learning activities.*
CFD1:	Relevant	*I would recommend the Clubs to be extended to all grades as well. Because they are more worthy to the learners so that they should be exposed to different techniques on how to count. Also the time to be extended at least twice a week. More schools should be involved in this Programme by doing so our results will be improved/good. Looking forward to the Programme in 2017.!!*
CFE1:	No response	*None*

Table 9h: club facilitators responses on item 4 of the post-club teacher questionnaire

Item 3: What was your experience of working with **learners** in the club space compared to that of the classroom with respect to; -

e. what you learnt about teaching mathematics through games, particularly card and dice games?

Respondents	Response category	Responses
CFA1:	Relevant	*I think that most primary school still need to use the concrete materials for teaching and learning. They learn easy through play and enjoy the games.*
CFB1:	Relevant	*In the classroom situation, I use them just to keep learners occupied, while in the club space I use them to solve specific challenges learners face in Mathematics*
CFC1:	Relevant	*Learners love games and they like to compete against each other. They learn as they play. They learn basic skills of mathematics. They are able to teach others in a group.*
CFD1:	Relevant	*Wooow it's the most enjoyable part it makes them to be quick thinkers also encourages them to think before the write/give the answer*
CFE1:	Relevant	*That is a fun way of learning, it motivated the learners, possitiveness came through, independence came through, not afraid of assessments that they can do the tasks at home and at school.*

Table 9g: club facilitators responses on item 3e of the post-club teacher questionnaire

Appendix Six – Interview transcripts

Pre-Interview teacher questions:

CF Mazeli. N.

Part A: Participant Information | **Date:** 20/08/2017

Name (if you wish to provide it):

Club site code (School): Hlinge P.S. (A) **Number of club members:** 12.

1. Can you describe how you felt as a facilitator in the club space?

I felt empowered because there are strategies that we learnt from the workshop

2. Describe your experience of working with the supportive club ethos

The learners enjoyed the mathematics games, card, dice games. They learn through play.

3. What was your experience of working with **learners** in the club space compared to that of the classroom with respect to; -

   a. Can you describe how you tracked changes in learners' progression over the 15-weeks, after doing the baseline assessment?

The learners get more individual attention because they were few (12), as a results learners were actively participating there were change in their results.

   b. Did the club activities and assessment tools help you gain sufficient insight into learners changing understanding of mathematical concepts?

Yes. They learn new strategies like family members in addition, and mathematical concepts.

c. What did you learn about how to extend learners during activities?

Give them more time if they do not understand the activity.

d. Can you describe how you felt about the learners working in groups and pairs?

They help one another, they understand better when they explain to each other.

e. What did you learn about teaching mathematics through games, particularly card and dice games?

Learners enjoyed the games and being not aware they are learning but they learn freely.

4. Is there any other information that you would like to share?

The mathematics games changed their attitude towards mathematics. This has boosted their self-confidence.

Thank you for your time.

Teacher interview questions: **Pre- and post- club learner mathematical progression and disposition**

Part A: Participant Information | **Date:** 05/02/2014

Name (if you wish to provide it): CFZ

Club site (School): C **Number of club members:** 12

TIME: 11:41 – 12:40

1. Were there any evident changes in the club learners' mathematical proficiency after participating in after school maths clubs?

Yes, confidence, independente in learners.

2. What do you think allowed those shifts to happen?

The strategies that were used in Maths club that make theose learners to be more informed or able to calculate using 4 Maths operation sighs

3. Is there a particular strategy or activity you used during the club to promote progression more than others?

Number-line method helped a lot in addition and subtraction of bigger number with 2 to 3 digit number, for instance Game - bonds of ten activity was always helping when adding numbers.

4. Would you attribute such evolution to your awareness (experience or expertise)?

Yes, for some of the learners for instance Peters Nanger, a grade 6 learner could not work on his own or complete a homework, due to participation in this programme he became able to work on his own and complete his homework with confidence.

5. How do you feel about the strategies and games used in the clubs?

Exciting, These strategies changed my traditional Maths class atmosphere into fun, relaxed class.

12. Did the learners interact or work together before and after club participation?
They were shy before, but after you could see smile in their faces.

13. Others didn't make any progress? What could be the reason?
Referral cases.

14. Are there any benefits for learners by being in the club space?
Uncover the potential for Maths based careers which would have been buried if a learner was not exposed to Maths club.

15. Would you encourage learners to participate in future?
Yes, even for each and every grade
Yes, to unleash the love for Maths and drive away the misconception that Maths is difficult

16. Would you encourage your peers to participate in future?
Yes, even for each and every grade in the school to fill content Gaps, and eradicate misconceptions.

17. Is there any other information that you would like to share?
The Maths Club concept should be spread as wide as possible in order to help teachers and learners to form a solid foundation for Mathematics

Thank you for your time.