A participatory community-based strategy to improve Grade 4 learners' number sense in multiplication

by

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DECLARATION

Student number: 2016255834

I, Gerrit Cloete, declare that this dissertation titled: “A participatory community-based Strategy to improve Grade 4 learners’ number sense in multiplication” is my own work and I have never submitted it for any qualification before. I have acknowledged all sources by using complete references.

_____ _____2024/06/26_____

Signature Date

G. Cloete

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DEDICATION

For the top of my tree to reach high into the sky, the roots must reach hell. This voluntary suffering has broken and rebuilt me stronger and wiser. I wish to mention people who made the suffering tolerable:

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ABSTRACT

This study investigates how a community-based participatory approach improved grade 4 learners' number sense in multiplication. Using a mixed-methods approach, the study followed a participatory action research methodology with one cycle. Three hundred and twenty eight participants, ten in the team and the rest, grade four learners, were selected through convenience sampling.

Quantitative data came from Pre-Tests and Post-Tests. The study employed a quantitative approach to examine the premise that a community-based participation strategy would result in a noteworthy enhancement of student performance. Data was analysed using statistical analysis as well as content analyses. The results showed that the Grade 4 cohort's multiplication scores had increased by 20%, showing significant improvements in mathematical competency. Teachers' joint efforts in creating and putting into practice engaging, student-centered teaching approaches, were credited with this increase.

Qualitative data came from team meetings, focus group discussions and participant feedback. Data was analysed using narrative analysis. Data was coded, categorised and then themes emerged. Three themes were identified, knowledge needed by SEDC team, collaborative innovation in teaching and learning, classroom organisation and discipline. The aforementioned topics emphasized the significance of cooperative planning and accommodating varied learning styles to enhance academic achievements.

A hypothesis and the research questions aimed to answer if a PCBS could improve the number sense of Gr. 4 learners pertaining to multiplication. Evidence gathered suggested a PCBS could improve Gr. 4 learners' number sense with regard to multiplication.

The quantitative data showed an overall improvement in test scores across the spectrum of the Gr. 4 learners. Qualitative data from the planning session on the intervention indicate that collaboration could be a better way to improve student learning. Qualitative data from the general feedback on the intervention indicate that classroom discipline is necessary to execute a strategy.

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LIST OF ABBREVIATIONS

PCBS: Participatory community-based strategy

SEDC: Socio-economic development company

TA: Teachers' assistant

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CHAPTER 1: BACKGROUND TO THE STUDY

The researcher is working for a Socio Economic Development Company (SEDC) that is funded by wind and solar farms. The SEDC has a mathematics focus. The researcher started working on a project firstly in Douglas and then in De Aar and has observed that learners, in the primary and secondary grades, perform poorly in number sense. Initially, Grade 12 and Grade 9 mathematics were the focus. Later, the project aim was to start, from Grade 1, to enhance conceptual, rather than procedural understanding in mathematics, based on observation and unsolicited responses from teachers and principals that the number sense (and results) of learners had been improved by the SEDC project. Therefore, the study will investigate whether the participatory community-based strategy improves the number sense of Grade 4 learners with regard to multiplication.

1.1 SOCIO-ECONOMIC DEVELOPMENT COMPANY

1.1.1 What is a SEDC?

A Socio-economic development company (SEDC) or a Community Development Corporation (CDC) to use the alternative American terminology, has a niche in a community that has become neglected and isolated, largely due to governmental decisions and policies (National Research Council, 1993). Isolation in this context means cultural, racial, economic and geographical. This isolation can result in a situation where half the community are outside the formal economy and can lead to unacceptably high impoverished conditions. “In this context one finds depressing social features shared by numerous other urban ghettos, most notably ill health, stress, the adverse effects of drug dependency, family fragmentation, school truancy and exceptionally high levels of inter-personal conflict, especially domestic violence and assaults involving knives and guns” (Benjamin, 2005, p. 11).

Where decisions and policies have created a low socio-economic community, a SEDC then partners with local government and local institutions to improve one or more strained government agencies.

These improvement efforts are made by partnering SEDC employees with local community members to collectively engage in community development.

Upgrading communal spaces, improving local healthcare, and improving local schools are part of the plan. School development may focus on the school buildings, school management, school community engagement and improving pedagogical practices. Pedagogical practices can include assisting teachers or learners or both teachers and learners, either generally or in specific aspects of teaching and learning.

1.1.2 Why is there a need for SEDC?

More than 30% and in some areas over 50% of the people in South Africa are NEET- Not in Education, Employment or Training (Zuber-Skerrit et al., 2020, p. 36). Low numbers of taxpayers and government policies have put strain on educational, health and social welfare systems; therefore, it is imperative that communities empower themselves and one such way is through community-based research that provides an educative, emancipatory, and political process (Zuber-Skerrit et al., 2020, p. 40).

1.2 WHAT NUMBER SENSE IS AND WHY IT IS IMPORTANT

The researcher finds resonance with and invites the reader to share in Greeno's (1991, p. 170) view of number sense "as situated knowing in a conceptual domain" whereby number sense is seen metaphorically as a physical environment that one inhabits, and depending on how skilful one uses resources (numbers and operations) and the help one receives; one either thrives or struggles in this environment. Developing number sense in another has to start with having number sense yourself (Courtney-Clarke & Wessels, 2014, p. 3).

Anyone, including teachers, lacking number sense, will struggle to answer learners' higher-order questions when required to apply their resources of knowledge to new situations (Sousa, 2015, p. 52).

Mature number sense (or just number sense) henceforth, starts developing in Grade 4 and refers to procedures and structures learners need to master for accurate calculations with more abstract number concepts (Hansen, 2019, p. 1).

A person possessing good number sense will be mathematically proficient and will have the following characteristics: a good conceptual understanding, be procedurally fluent, have strategic competence, able to

use adaptive reasoning and have a productive disposition (Courtney-Clarke & Wessels, 2014).

1.3 THE RATIONALE FOR TEACHING MULTIPLICATION STRATEGIES FOR IMPROVED NUMBER SENSE

The best way to improve number sense is the effective teaching and learning of mental calculation strategies (Hansen, 2019, p. 2). Mental calculation strategies help learners learn procedures and structures they need to master for accurate calculations with more abstract number concepts, thus improving their number sense. It is widely accepted that the automatic retrieval of multiplication facts empowers learners to solve problems, leading quickly and accurately to fewer errors, solve more complex parts of a problem and build the foundation for more complex aspects of mathematics, such as division, fractions and factorisation that are all needed in algebra. Being able to mentally calculate multiplication problems quickly and accurately also builds learners' confidence and it counters what is termed "learned helplessness" in mathematics (Woodard, 2006, p. 278).

All healthy children across creed, colour or culture have the inborn ability to develop number sense; however, these abilities need to be developed and teachers need to know the stages and difficulties their learners will experience whilst acquiring number sense (Hansen, 2019).

Unfortunately, if students do not achieve mastery of multiplication facts by age 12 (end of Intermediate phase), they are unlikely to achieve fluency or mastery of this skill and will not only not be able to solve problems quickly and accurately, but also forgo all of the above benefits and most likely not perform well in mathematics throughout their schooling (Evans & Wong, 2007, p. 89).

Countless learners find memorising and learning their multiplication facts hard and have difficulty using them accurately and quickly (Sousa, 2015, p. 33). As our society develops and transforms, we must find ways in our communities through participation, to help learners and teachers develop their number sense, where new strategies and improved teacher knowledge will be key.

Successful strategies for improving multiplication facts in the intermediate phase include: the use of computer programs; flash cards; peer tutoring; small group tutoring; worksheets (pencil and paper); songs; use of the

hands and simple tricks to find multiples of 6, 7 and 9 (Evans & Wong, 2007; Gallagher, 2006; Tonizzi et al., 2020). Rote learning might have negative connotations, but there are many benefits to automatic fact retrieval and fluency, amongst other things, freeing up mental capacity for higher order problem solving (Evans & Wong, 2007, p. 3).

The choice of an effective strategy seems situational and dependant on the available resources. Funding for the project from the wind and solar farms provide for two teachers and about ten Teacher Assistants (TA's). The situation in the rural Northern Cape will discount technology-based strategies, but there are low tech resources and people from the local community. Therefore, the strategy will use low tech resources and local community members but should empower both the learners and the community members in their roles as TA's.

1.4 WHAT IS IMPORTANT WHEN USING PARTICIPATORY COMMUNITY-BASED STRATEGY

The following section will aim to clarify what is meant by participatory community-based strategy (PCBS).

1.4.1 WHAT IS PCBS?

Participatory in the sense of this study has a dual meaning. Since the multiplication improvement project takes place in a larger and long-term socio-economic development project, participatory will refer to the participants and their collective effort within the smaller multiplication project. Participatory also refers to the way the participants will try to bring about a meaningful change through participatory action research (PAR). Action research (AR) will be introduced to the participants in the build-up to the multiplication intervention; thereafter, participants will contribute to PAR for the intervention.

Community based again refers to both the wider local community that will include the schooling community and in the narrower sense community will refer to the core participants involved in the PAR. The participants are local community members and thus their ties and knowledge of the community is essential to bring about solutions that can be used locally and possibly be useful, globally. The narrow community and the wider community are interconnected, and the changes sought by the few cannot be done without the involvement of the many.

Strategy is generally considered to be a plan to achieve a long-term goal. Moreover, a strategy is a complete plan that can be repeated with different, same skilled persons, to yield the same result. Strategy is also widely used in the tactics of war; in this sense, we could be waging a war on poor (mathematics) education in disadvantaged communities. A plan or strategy within project management would be the optimal use of the time, scope, and budget parameters to bring about the desired outcome. In the case of the project, the time would be within a school term, the scope the intermediate phase (Gr. 4), and the budget would have to be within the normal parameters of the larger project. The strategy would thus involve the participation of the local community to make a difference in young learners' experience of an important part of mathematics.

1.4.2 PARADIGMS SUITABLE FOR PCBS

Creswell and Creswell (2014) are of the opinion that a PCBS as briefly explained above, would be situated either within the transformative or pragmatic paradigms.

Within the larger context, transformation is sought economically through the better education of learners, leading to more opportunities for them and the creation of well qualified teachers to continue this process. During the process of achieving the overall goal and the objectives of the multiplication intervention, the participants could likely be transformed themselves through their interactions within the community.

The pragmatic paradigm comes into play through the mode of bringing about the change. The use of PAR makes use of participants as useful contributors and the plans they devise could likely be goal orientated and entail what would likely work to solve the problem placed before them. The plans generated would not be from an expert with neatly laid out steps, but rather collectively devised and altered if needed to solve the problem. Taking the educational environment into consideration, tests and discussions and plans are all part of a possible solution.

1.5 RATIONALE AND PROBLEM STATEMENT

Often in the past seven years, the researcher has heard from teachers that they wish that intermediate phase mathematics could return the focus of teaching to basic operations, such as addition, subtraction, multiplication and division. The phrase "number sense" is mentioned 12 times in the Curriculum and Assessment Policy Statement (CAPS) documents for Grade R, 17 times for Grades 1-3, and once for Grades 4-

6. However, if one had to ask teachers to define number sense, they would struggle. What teachers are trying to articulate is that they have problems in the current progressive curriculum to effectively teach for number sense. Within this context, the researcher aims to answer the call of the (DPME/DBE, 2017, p. 28) stating:

Areas requiring the most urgent attention are programmes which enable primary school teachers to teach literacy and basic maths, and to practice formative assessment in support of these disciplines.

and (Thelebona et al., 2021, p. 185) in their paper titled*: "Don't Delay Learning": Igniting Promotion of Pedagogical Transformation Strategies in Early Childhood Care Education* asking for "Collaboration with Social Justice-oriented Stakeholders" to transform early childhood education. The researcher wishes to ameliorate the ineffective teaching for number sense by using local community members to support the teaching and learning of mathematics with a particular focus on multiplication. Using a participatory community-based approach could empower and emancipate everyone involved (Kemmis & McTaggart, 2007).

1.6 HYPOTHESIS AND RESEARCH QUESTIONS

Statistical data analyses lend itself to hypotheses to gauge the effect, if any of the intervention, therefore they are:

- H_0 = There will be no significant difference in marks from Pre-Test to Post-Test after the PCBS was used to administer a multiplication intervention.
- H_1 = There will be an increase in marks from Pre-Test to Post-Test after the PCBS was used to administer a multiplication intervention.

The null hypothesis states that there will be no improvement and the alternative hypothesis states there will be an improvement in Gr. 4 marks.

The study aims to answer the following research question:

How can a participatory community-based strategy improve Grade 4 learners' number sense in multiplication?

The secondary research questions of the study are as follows:

- What knowledge is needed by SEDC teachers and assistants to teach Grade 4 multiplication facts using a participatory community-based strategy?
- How can SEDC teachers and assistants use a participatory community-based strategy to teach Grade 4 multiplication facts to learners?

1.7 AIM OF THE STUDY

The aim of this study is to investigate whether a participatory community-based strategy can improve the number sense of Grade 4 learners, particularly concerning multiplication facts.

1.8 OBJECTIVES OF THE STUDY

The objectives of the research are:

- to identify the knowledge needed by SEDC teachers and assistants to teach Grade 4 multiplication facts using a participatory community-based strategy; and
- to establish how SEDC teachers and assistants use a participatory community-based strategy to teach Grade 4 multiplication facts to learners.

1.9 SIGNIFICANCE OF THE STUDY

To the researcher's knowledge, using the participatory community-based strategy in the teaching and learning of number sense during school teaching time, has not been investigated. Most community strategies are used after school teaching time for supporting learners with homework. Thus, there is a dearth of research in this area, which the proposed study aims to fill.

The local community will benefit by having their Grade 4 learners improve their number sense in multiplication. Teacher Assistants will benefit from practical experience in their field of study and are likely to be employed locally, continuing to utilise the skills they learnt during this study that might benefit future generations of the local community, by having competent mathematics teachers. Local mathematics teachers will benefit by having learners with better number sense and a permanent teacher assistant to assist them in their classroom.

1.10 RESEARCH METHODOLOGY

The critical or transformative paradigm is used to place the research. In order to evaluate the outcomes of this study more broadly qualitative and quantitative methods will be used. Usually a mixed methods approach would fall into the pragmatic paradigm; however, scholars, such as Romm (2015) and Dick (2015) concur that participatory action research (PAR) is able to use both qualitative and quantitative methods to fulfil this paradigm's objectives. Using a mixed method approach will aid in providing rich descriptions of both the mathematics and community aspect of the research within an educational context.

1.10.1 Research design: participatory action research

This study will use both qualitative and quantitative research designs to conduct participatory action research. According to Katoppo and Sudradjat (2015, p. 122), the repeating action-reflection cycles integrate practice and theory. Phases of planning, action, observation, and reflection will be used and repeated, if necessary, to fulfil the research aims and objectives (Burns, 2009, p. 290). This study follows a convergent parallel design where errors made by Gr.4 learners are observed and a strategy is collaboratively devised by the SEDC team for the teaching and learning of multiplication facts. Thereafter, an intervention is administered to the Gr. 4 learners.

In preparation for the Gr. 4 PAR intervention, the Gr. 4 Multiplication test and a number sense test (Courtney-Clarke & Wessels, 2014) was written by the SEDC team to determine their own number sense and multiplication fluency; 50% for the number sense test and 90% for the Gr. 4 Multiplication test, respectively. This is deemed sufficient for the SEDC team to assist the learners.

The Gr. 4 learners will write a pre-test and based on this test, will receive interventions and write a post-test. Test scores and team discussion will determine the success of the intervention.

CHAPTER 2: CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

Introduction

This chapter will serve as a foundation for the study, wherein the problems and possible solutions to the problems are elaborated. The problem of poor number sense is a global one and is also affecting our local community. Thus, a solution should aid the local community, but also have a global application to aid other communities facing similar challenges. The ways in which a community can collaborate and help themselves will be broadly described, with a particular focus on solutions that are suitable in the context of the research. Therefore, contextual or experiential learning within a community will be described and the advantages and barriers noted. Following this, the problems and solutions found to the teaching and learning of mathematics will guide the co-researchers to the more correct teaching strategies, so as to avoid barriers in mathematics learning. Then teaching and learning strategies for number sense with a focus on multiplication will be clarified.

By using local youths as TA's in local schools to assist teachers and learners, the SEDC's operations are included in contextual learning within a community. Therefore, an elaboration on what Community Based Learning (CBL) is, the purpose, outcomes, and advantages, as well as barriers to CBL will follow.

2.1 THE GLOBAL COMMUNITY AND NUMBER SENSE

Globally, the poor teaching and learning for number sense has been investigated in Australia (Carr et al., 2020), the United States of America (Fuchs et al., 2013), Malaysia (Seffetullah et al., 2017) and Italy (Tonizzi, 2020). In Namibia, a former province of South Africa, (Courtney-Clarke & Wessels, 2014, p. 8) found that primary school teachers lacked common content knowledge, as well as specialised content knowledge and had very low number sense themselves.

Regarding South African teachers, it has been found that between two-thirds and three-quarters of mathematics teachers do not have sufficient knowledge of the subject matter to teach mathematics (DPME/DBE, 2017, p. 3). It is very likely that lacking knowledge in the same areas as

Namibian teachers, the number sense of South African teachers will also be low and reflected in low learners' scores (Feza, 2018, p. 72).

If subject matter knowledge is lacking, it is reasonable to infer those other aspects of pedagogical content knowledge is also weak, such as the mathematical horizon (teaching skills that will be useful in future). Therefore, it is probable that learners' results will worsen as they progress in grades; hence, a strategy that will complement the teaching and learning of number sense is crucial. Learners' low scores are the result of conventional mathematics instruction, which is mostly attentive to mastering algorithms and rules, instead of developing number sense (Seffetullah et al., 2017, p. 595).

2.1.1 The local community and Number Sense

In South Africa (Graven et al., 2013), a call for assessing mental calculation skills to improve number sense has been made. According to the report of the Department of Basic Education (DBE, 2014, p. 51) on the Annual National Assessment, which is designed to test the numeracy of learners, the average scores of Grade 4 learners for mathematics in the Northern Cape were as follows: 34,9% in 2012; 32,1% in 2013, and 34,5% in 2014. It is widely accepted that there is a persistent downward trend in mathematics performance when the results for Grades 3, 6 and 9 are compared. The Northern Cape had the same trend in 2015, 2016 and 2017, with the 2017 results of learners who passed mathematics in Grades 3, 6 and 9 as follows: Grade 3 – 94%; Grade 6 – 89,7%; and Grade 9 – 37,3% (Nkoane, 2017). In 2017, the Grade 4 pass rate was 76,2%, and the average result of learners for mathematics in the Northern Cape was 52,2% (Nkoane, 2017). In the same year, the result for Pixly ka Seme was 50%, with most learners attaining Level 3 or, secondly, Level 4 out of a possible 7 (Nkoane, 2017). After the first term of 2018, the average Grade 4 score for mathematics was 50,7% (Nkoane, 2018).

Since the problem of poor number sense seeks to be solved by a Socio-Economic Development Company (SEDC) this term, its aims will be clarified. Descriptions will move from general to the SEDC's specific aims.

2.2 HOW CAN COMMUNITIES BE EMPOWERED?

2.2.1 Suggestions from research on community empowerment

It is suggested that communities that need development be seen rather as an asset (than a liability) and that such development - building human, social, physical, financial, cultural, and political capital - should be done in collaboration with the community (Nickels, 2015, p. 141).

Strategies that engage learners in learning through community-based solutions seek to create both citizens and students. Community-based learning strategies include civic education; academically based community service; environmental education; service learning; place-based learning, and work-based learning (Melaville et al., 2006).

Community-based learning are sets of learning or teaching strategies that enable adults and youth to learn from any segments of the community. This definition provides for young and old learners to identify what they wish to learn in and from the community (Owens & Wang, 1996, p. 2). By community, Owens and Wang (1996) include the schools, formal and informal institutions in one's neighbourhood and the entire world, through such resources as the Internet.

The combination of action learning and participatory action research for participatory action learning and action research (PALAR), provides a comprehensive framework and methodology for community engagement projects with positive outcomes for all (Zuber-Skerritt, 2018, p. 514).

Community-based research through action learning within a PALAR process enables whole communities and individuals to develop and learn attitudes, skills, understandings, and values to participate in social action effectively for their specific contexts and needs, to become activists, creators of knowledge and self-directed learners (Zuber-Skerrit et al., 2020, p. 34).

2.2.2 Critical assumptions underlying community-based learning

Principles of community-based learning relate to the changing nature of society, the learner, the learning processes, sources for learning, and have the following underlying assumptions (Owens & Wang, 1996, p. 2):

- Lifelong education will play an important process in learning, from preschool to adulthood; the learner will play several roles in their own and the community’s education.

- Learning requires the full participation of the mentor/teacher, as well as the learner.
- Future occupations will require more education, but a type of education inclusive of teamwork, critical thinking, and knowledge application is needed.
- Community affairs require adults to balance family, work, and community responsibilities.
- Schools alone cannot solve all the problems of today's learners and contributions from the family, business, the community, labour, and additional agencies are vital.
- Resistance by some communities, schools, and teachers towards the changes suggested above can be expected. These groups should see the need for change and then be helped to feel empowered to implement these changes. This vision should be supported by suitable staff development and resources, for these changes to occur.

When considering ways to improve communities by improving schooling and using youths to aid in its development, there are several factors to consider for the project to be successful (National Research Council, 1993).

2.2.3 Examples of community-based learning programmes

Examples of community-based learning programmes share many similarities and can include Service learning; Experience-based Career Education; Cooperative Education, Youth Apprenticeship (Owens & Wang, 1996) and Place-based Learning, as well as Work-based Learning (Melaville et al., 2006).

Service learning

As a method of learning and teaching, service learning has four defining characteristics (Owens & Wang, 1996, p. 3):

1. Youth development and learning by active participation in organised service practices to meet the community needs and are coordinated within the community and school.

2. An integrated academic curriculum provides structured time for youth to talk, think and write about what they observed and did during the service-learning process.

3. Provides youth with chances to use newly acquired knowledge and theoretic skills in real-life situations within their own communities.

4. Develops a sense of caring for the community by enhancing what is learnt and taught at school, by bringing the student and community together.

Experience-Based Career Education

Experience Based Career Education combines the subject matter undergraduates normally study, with contact and knowledge about people, self, jobs, and how the community works, letting school learners and students learn through direct interaction under the supervision and guidance of mentors (Owens & Wang, 1996, p. 3).

Cooperative Education

Cooperative Education usually takes the form of a public-private partnership where private institutions take an early interest in school learners. They provide funds for learners' guidance through learners' high school years, with the understanding that these learners will be employed by the private institution for a set amount of time, starting while learners are at school and continuing after schooling is completed (Owens & Wang, 1996, p. 4). The focus is on academic achievement, career guidance and work readiness.

Youth Apprenticeship

Youth Apprenticeship involves the workplace as a learning environment, creating opportunities for mentor-relationships by providing adult role models, and thus developing high levels of vocational and academic skills required by employers (Owens & Wang, 1996, p. 5).

Place-Based Learning

Place-based learning utilises the unique culture, history, environment, and economy of a location to provide a learning context, where community members are partners and are used as resources in every aspect of learning and teaching (Melaville et al., 2006, p. 8).

Work-Based Learning

Work-based learning partners young people with adults to gain role models, mentorship or informational interactions and learn industry standards through applied and contextual learning. This learning should

ideally start from preschool and continue to graduation or even further if possible (Melaville et al., 2006, p. 9).

By using the common characteristics of Service learning; Experience-based Career Education; Cooperative Education; Youth Apprenticeship; Place-based learning and Work-based learning, a viable way to meet community needs, provide academic opportunities to youth, and equip youth with skills that employers will value, can be achieved. All the afore-mentioned programmes use meaningful content; let students participate in decision-making; learn goals underpinning public purpose and personal achievement; strive for learning from both successes and failures, and increase relationships and resources for student action and learning.

From the descriptions above, community projects that use schools for community-based learning could have as participants, school learners; teachers; school principals; parents of learners; school management teams; the Department of Education; private sponsors, and tertiary academic institutions.

2.2.4 Learning strategies of community-based learning

Owens and Wang (1996, p. 6) describe three critical steps for any community-based learning project:

- Framing (planning): Mentor/Teacher and student(s) collectively decide the objectives of learning.
- Activity: The middle step is the learning activity itself that can either be complex with lots of steps or simple.
- Reflection (debriefing): This step can be done with a mentor and individual student or as a group. Debriefing focuses on what went wrong, what went right, and what was unexpected. Reflection is used to plan the next activity.

This description is very similar to a participatory action research cycle that uses a - Plan, Act, Observe and Reflect- cycle. However, it is not implicitly called that and this could be that participants could still be learning to frame, act and reflect. To reflect, learning to observe should first be taught. This non-descript participatory action research cycle could also be because of the fact that many practitioners within the community-based learning milieu are self-taught and not familiar with research practices (Ahmed et al., 2004, p. 143).

The role of mentors in community-based education cannot be overstated, with a reliable strong bond fostering developmental relationships through mutual enjoyment of chosen activities, rather than prescriptive relationships (Owens & Wang, 1996; Nickels, 2015).

Learning processes of community-based learning are grounded in cognitive research which states that intelligence and expertise come from interaction with the environment, as opposed to isolation from the environment; thus, effective learning engages hand and head or doing and knowing. Effective learning environments include content; sequence; teaching methods, and sociology (Owens & Wang, 1996, p. 6) and are defined below:

- Content: Includes knowledge domains, such as mathematics; expert problem solving; planning, and thinking about and exploring new content.
- Teaching methods: help students engage in, observe, discover, or invent good strategies in context. Included are coaching; modelling and scaffolding; articulation of problem-solving strategies; reflection of one's own strategy with others' strategies, and finally, exploration in problem solving.
- Sequencing: moving from simple to more complex problems and concepts, thus increasing skills and strategies available for problem solving.
- Sociology of learning: creating real-world environments for learning, through active communication with experts, intrinsic learning motivation, and cooperative and competitive learning where learning takes place by learning with and from one another.

The best learning environment intentionally connects home, school and community (Melaville et al., 2006, p. 37). Learning situated in work related, practical contexts is both more effective and faster than in a decontextualised environment.

Cognitive research applications for the workplace (Owens & Wang, 1996, p. 8) reminds us that we learn from our individual experiences; hence, the best learning occurs when one directs one's own learning. Learning is most effective in context, when learning is linked to work directly. Open communication and collaboration enable persons to learn from one another. Knowledge is continuously created, and learning how to capture and share this new knowledge with others is important. Learning can be

unconscious and thus questioning and recognising our tacit assumptions is important.

2.2.5 Outcomes of community-based learning

The shared outcomes of community-based learning are positive personal growth and development; increased academic learning and intellectual development; and lastly, constructive social growth and development (Owens & Wang, 1996). There is emphasis on a holistic, structured programme with mentorship and inclusion, with partners encompassing the whole community, helping to achieve a worthwhile goal.

Academic outcomes of community-based learning can include (Melaville et al., 2006, p. 23): increase in teachers' enthusiasm, increased student engagement and academic achievement, increased knowledge of natural and social environment, reduced classroom behavioural problems, increase class attendance, selection of challenging classes such as mathematics and science, and reduced dropout rates.

Personal and social outcomes of community-based learning include: reduced teen pregnancy rates, increased competence and autonomy, empowerment, increased confidence and skills, higher grades for mentored students, acceptance of diversity and avoidance of risky behaviours (Melaville et al., 2006, p. 24).

Work outcomes from community-based learning may include: job readiness, job specific skills, positive correlation with future employment and wages, learners require less training, better work ethics, working better within teams, better career aspirations and skills, desire for continued education and more satisfying careers (Melaville et al., 2006, p. 25).

2.2.4 Example of a local community project

In the development and evaluation of a metacognitive programme for young learners in the South African context three big community development strategies from the United States of America about educational programmes were analysed for best practices (Benjamin, 2005, p. 95). Major concerns in the South African context are threefold, firstly - teacher and curriculum issues; secondly - insufficient early childhood education and thirdly – the lack of support for inclusive education (Benjamin, 2005, p. 9).

Benjamin's research led to creating the Basic Concepts Mediated Learning Programme to bridge the scholastic deficit in basic concepts frequently observed amongst young children in low socio-economic areas such as the Cape Flats and the rural Northern Cape. The program is based on the major learning theories of Piaget, Vygotsky and Feuerstein that provide descriptions of mental operations of thinking, emphasises the systematic introduction of symbolic mediators and expands the role the human mediator plays in furthering cognitive modifiability (Benjamin, 2005, p. 18). A metacognitive, intensive, short-term, semi-structured, small group, mediated programme was found to be effective in bridging the scholastic gap in basic concepts frequently observed amongst young children in low socio-economic areas.

Benjamin (2005, p. 104) defines the above terms as such:

- Metacognitive: Thinking about one's thinking or selection, development, and application of one's personal thinking processes.
- Intensive: Intensity is defined as the frequency of contact between mediator and students, e.g., twice weekly for 30 minutes per session. Programmes can be low or high intensity (Tonizzi et al., 2020).
- Short-term: Term refers to the duration of the programme, e.g., two school terms or six months.
- Semi-structured: Structure is provided in some form for the mediator through a manual or training, but the mediator must create a plan to deliver the structured content to learners.
- Small group: Five to eight learners who can interact with one another and/or with the mediator.
- Mediated: A mediator acts as a more knowledgeable other to guide learners' learning by ensuring engagement between the child, the learning material, and the mediator.

2.5 BARRIERS TO COMMUNITY-BASED LEARNING PROJECTS

With all the possible, positive outcomes of community-based learning mentioned earlier in this chapter, one would wonder why every community is not actively pursuing this means of education? Several factors hinder the integration of community-based learning into education and these will be discussed below. These factors are practical, theoretical, institutional, and individual (personal) barriers.

2.5.1 Practical barriers to community-based learning

2.4.1.1 Lack of skills

Anyone attempting community development must have cultural competency to work within a heterogeneous group of persons different from them. Moreover, team-based learning that fosters team building, accountability, and interpersonal communication, so that both insider and outsider voices can be heard is recommended (Nickels, 2015, p. 141). Very few tertiary courses are available that teach community-based learning skills and give adequate practical exposure to such endeavours, resulting in a shortage of people with the knowledge and skills to implement successful community based-learning programmes.

2.4.1.2 Time, Effort and Expense.

Community-based learning demands time for planning projects and outcomes within projects; mentoring takes time; finding the right partners for the different roles within a project takes time; developing participants' skills need time, and reflecting on all aspects within a programme also requires time (Nickels, 2015; Ahmed et al., 2004; Owens & Wang, 1996). Community problems in low socio-economic areas are not fixed overnight; long-term commitment from all stakeholders, including private funders, is necessary to bring about meaningful change (Ahmed et al., 2004, p. 147).

Major efforts from community-based participatory researchers will be required for developing their own skills and turning a diverse group of participants into a cohesive unit. Even arranging and sorting transport issues within a project will require effort (Owens & Wang, 1996, p. 11).

The training of teachers and community members is most often a necessity and will incur some expense. Salaries and stipends, learning materials, and study fees and incentives are major expenses in some educational projects (Owens & Wang, 1996, p. 11).

2.5.2 Theoretical barriers to community-based learning

Many educators cling to an older paradigm of pedagogy where an educator's role is to impart knowledge to learners and then test the learners to see how much they can recall; this teaching strategy excludes mentorship (Owens & Wang, 1996, p. 11). A trustworthy companion of this outdated paradigm of pedagogy is the belief that subject matter (content), should be the main driver in education. This leads to decontextualised learning experiences if educators and community

members feel community-based activities detract from learning subject matter only.

The full integration of community-based learning into the whole school curriculum is believed to bring about more positive changes for learners. However, most community-based learning programmes focus only on particular subjects or courses (Melaville et al., 2006, p. 29). A very probable example in South Africa would be if the DBE temporarily employs teacher assistants, with first language and mathematics to be prioritised to receive teacher assistants.

Straddling practical and theoretical barriers is the fact that both student and project outcomes of community-based education programmes are hard to measure, quantify and uniformly evaluate (Owens & Wang, 1996, p. 12).

2.5.3 Institutional barriers

There is a void of community-based participatory researchers due to tertiary institutions not training enough of these researchers, leading to few people with the skills and experience to do community-based research (Ahmed et al., 2004, p. 142).

Objectification is a theoretical barrier, rooted in institutional inertia to community-based learning research, where community members are seen as 'objects' and not participants. This increases the reluctance of the community to participate in research projects and fuels distrust in outsiders, thus hindering community-based participatory research (Ahmed et al., 2004, p. 143). Sharing the same train of thought is the hindrance that community knowledge is of little value and not respected by "traditional" researchers, thus encumbering reciprocal learning (Ahmed et al., 2004, p. 144).

A lack of understanding of the community based participatory research (CBPR) process by key-decision makers at tertiary institutions leads to fewer properly trained researchers and context in qualitative research is lost. Furthermore, this lack of high-level researchers leads to a lack of role models and mentors in CBPR, limited CBPR in faculties and thus a lack of CBPR advocacy and the promotion thereof. There are fewer grants and incentives available to CBPR than other types of (medical) research, reducing the number of researchers willing to pursue this career path. CBPR is seen more as community service and less of an academic

achievement, which also discourages CBPR as it is not awarded the same merit as other types of research (Ahmed et al., 2004, p. 145).

2.5.4 Individual barriers

Ahmed, Beck, Maurana and Newton (2004, p. 147) avows the following as barriers individuals or researchers might experience pertaining to CBPR:

- Few researchers have had proper training and practical experience, therefore lack the many skills required in CBPR. Piloting a small-scale project will provide many skills to prospective CBPR researchers. However, this will require a great deal of effort from the individual.
- There could be a lack of interest in CBPR, as discussed in the previous section.
- Fear of the unknown; standard research would be “much more comfortable” for most researchers. In addition, there is the loss of power and control that might not sit well with some researchers. Reflection and critical self-reflection can be uncomfortable.
- Maintaining many relationships within CBPR will take significant effort and can dissuade some researchers. Maintaining a lot of relationships with a diverse number of people for an extended period, will require even more effort.

2.6 The big picture pertaining to this community-based project.

A Socio-economic Development Company (SEDC) or a Community Development Corporation (CDC) to use American terminology, has a niche in a community that has become neglected and isolated, largely due to governmental decisions and policies (National Research Council, 1993). Isolation in this context means cultural, racial, economic, and geographical. This isolation can result in a situation where half the community is outside the formal economy and can lead to unacceptably impoverished conditions. “In this context one finds depressing social features shared by numerous other urban ghettos, most notably ill health, stress, the adverse effects of drug dependency, family fragmentation, school truancy and exceptionally high levels of inter-personal conflict, especially domestic violence and assaults involving knives and guns” (Benjamin, 2005, p. 11).

Where decisions and policies have created a low socio-economic community, a SEDC then partners with local government and local institutions to improve one or more strained government agencies.

These improvement efforts are made by partnering SEDC employees with local community members to collectively engage in community development, such as upgrading communal spaces, improving local healthcare and improving local schools. School development can focus on the school buildings, school management, school community engagement and improving pedagogical practices. Pedagogical practices can include assisting teachers or learners or both, either generally or in specific aspects of teaching and learning.

2.7 TEACHING FOR NUMBER SENSE

Number sense has three phases (Ben-Yuhuda & Sharoni, 2021). Young learners develop elementary calculation skills steadily from a procedural-experimental state to memorisation-based mastery. Number sense is a critical milestone in the development of young learners' ability to gain mastery of calculation. There is an initial phase where children experiment with strategies, such as finger counting, counting objects, or verbal counting. In the second phase, learners develop thinking strategies and use prior knowledge sensibly. Phases one and two establish an understanding of numerical procedures and principles, which provide the foundation for the development of number sense. Gradually, in the third phase, learners become capable of speedy, efficient, and accurate calculation. Learners can retrieve answers from a facts pool of stored memories. However, not all learners reach the third phase of number sense. Associating facts with meaning enables automatic mental calculation and commitment to memory.

Teaching strategies refer to the methods teachers use to communicate skills and ideas to learners, whether tactile, visual, or verbal (Schoonen, 2016, p. 9). Someone who is good in mathematics and has good number sense will have a conceptual understanding, be procedurally fluent, have strategic competence, use adaptive reasoning, and have a productive disposition (Courtney-Clarke & Wessels, 2014; Paulsen, 2019). Intervention strategies that increase number sense use estimation or mental calculations (Courtney-Clarke & Wessels, 2014, p. 4). Courtney-Clarke and Wessels (2014, p, 3) define the characteristics of a mathematically proficient person, who has number sense, below:

Conceptual understanding: The ability to represent problems in different ways and use the best representation depending on the situation, thus showing a functional and integrated understanding of mathematics.

Procedural fluency: Knowing how and when to use a procedure and using the procedure accurately, flexibly, and swiftly. The procedurally fluent use estimation to ensure their result is realistic. Having procedural fluency enables one to note conceptual interrelationships.

Strategic competence: The ability to devise a plan and solve problems. Good problem solvers can adapt their plans to the problem, form mental representations of the problem, and see mathematical relationships. Strategic competence is evident in fast mental calculations where the easiest method is selected to yield the correct answer.

Adaptive reasoning: The capacity to think logically, reflect on, explain, and justify the procedures used. Knowing what procedures work, why they work, how they work, and how procedures can be modified to answer the question, is crucial. Adaptive reasoning is the automatic regulation and monitoring of the problem-solving process.

Productive disposition: This is seeing mathematics as useful, sensible, and worthwhile, and seeing oneself as able to understand, learn and do mathematics. A productive disposition refers to the mind-set or established set of attitudes of the mathematically proficient.

Mathematics anxiety can serve as a barrier to learning mathematics (Paulsen, 2019, p. 249). The incorrect use of teaching strategies for multiplication facts, using rote memorisation, and speed drills, instead of focusing on understanding and sense making, can lead to mathematics anxiety (Boaler, 2015, p. 1).

The difference in performance amongst high and low performing students, was found to work without or with number sense respectively, or stated differently, using memorisation and procedures versus concepts and big ideas to solve problems (Boaler, 2016, p. 45).

Boaler (2015, p. 6) advocates the use of number talks to create number sense and enhance multiplication. Number talks entail the use and discussion of various strategies, comparing their similarities and differences, alongside their advantages and disadvantages. Furthermore, the use of various representations of number to enhance understanding of multiplication facts whilst aiding the development of number sense is

prescribed. Moreover, Boaler (2015, p. 4) is adamant that the use of number talks is the best way to increase number sense and math facts simultaneously. Corroborating this statement is the work of a 5th grade teacher who explored the use of number talks with her students for addition, and is now confident that number talks are effective and uses number talks for all four operations in her class (May, 2020, p. 372). Moreover, number talks increase numeracy, flexibility in choosing strategies, increase confidence for mental calculations, and improved accuracy, and students were able to solve problems faster (May, 2020, p. 371).

The act of physically writing is recommended for mathematics, number sense and multiplication strategies, as it engages more parts of the brain (Hansen, 2019), reduces cognitive load by not having to remember every step, and can be faster than multistep mental calculations (Ben-Yuhuda & Sharoni, 2021).

Direct retrieval of multiplication facts is the fastest and least error prone, than a mixture of derived facts and retrieval, than counting (Steel & Funnell, 2001). In contrast to Boaler (2016), who is against the use of speed and speeded practice to create multiplicative fluency, there was a call for the simultaneous development of concepts *and* speed (Allen-Lyall, 2018; Ben-Yuhuda & Sharoni, 2021).

Another way to support learning, is to appoint learner support assistants (Landsberg, 2019, p. 95).The current curriculum in South Africa is derived from the Australian curriculum. The Australian education system has seen a dramatic increase in the use of TA's (Cassim & Moen, 2020). It is likely that this trend will also be implemented in South Africa. A teacher assistant is an adult who can serve as a substitute; a more knowledgeable other to assist learners and help with various classroom tasks delegated to them by the teacher (Cassim & Moen, 2020). As the SEDC's purpose is to improve mathematics, TA's must be able to provide general classroom assistance, as well as specific mathematics instruction regarding the teaching of multiplication facts.

A more knowledgeable other is a constructivist term conceived by Vygotsky in his sociocultural learning theory and is defined as someone who can guide a child to master a concept or task by bridging what they can do independently, to what they can achieve with assistance; this area is where optimal learning takes place and is called the zone of proximal development or ZPD (Schoonen, 2016, p. 18). Scaffolding is what holds

the construction of a new concept in place, when a learner moves from what they know to a new concept (Schoonen, 2016, p. 19).

Schoonen (2016, p. 20) then sandwiches what the learner can accomplish independently, the ZPD and what the learner can accomplish with support between already allied cognitive tasks, and cognitive tasks the learner does not yet understand or has not heard of. These two outer layers to the original ZPD trinity can awaken negative feelings towards mathematics. In the already allied tasks category, feelings of boredom, a lack of interest, frustration, irritation, and disengagement can be awakened. In the category of *tasks, a learner does not yet understand* (and cannot scaffold), feelings of being too challenged, confusion, avoidance, insecurity, failure, fear and indifference, can be awakened towards mathematics. The latter layer and the feelings it evoke are the breeding ground for mathematics anxiety. Therefore, knowledge of Schoonen's (2016) interpretation of the ZPD is important in two ways to teachers and TA's; first, knowing where to start from, when teaching new concepts, and second, to avoid causing mathematics anxiety by trying to introduce concepts outside the ZPD. The effective creation of a new concept involving scaffolding and the correct guidance of a more knowledgeable other, is comparable to what Piaget calls the creation of a disequilibrium, incentivising the learner to learn and create a new concept. Inexperienced TA's may not know how to create this disequilibrium and may spoon-feed learners the answers, instead of guiding them towards the answer; consequently, this can also lead to boredom and an aversion to mathematics.

2.8 The use of Teachers' Assistants

TA's or learner support assistants should, in theory, identify barriers to learning in classes and in learners, then implement programmes to address these barriers, help assess learners' performance, as well as help evaluate the effectiveness of implemented programmes (Landsberg, 2019, p. 96).

Cassim and Moen (2020, p. 4) state three negatives regarding the use of TA's:
1) the costs involved that not all schools can afford;
2) differences in teaching styles of the teacher and the TA that can cause clashes between them, and
3) spoon-feeding of learners by inexperienced TA's that creates no learning of the subject matter.

Moreover, often untrained TA's focus more on task completion than on learning support (Landsberg, 2019).

Thus, training, payment and management of TA's will be required, and the latter component is proposed to be administered by the Head of Department at a school (Cassim & Moen, 2020, p. 11).

Cassim and Moen (2020, p. 3) aver that there are many benefits to using TA's and they are listed below:

- TA's can act as a known adult and serve as a substitute, a more knowledgeable other, if the teacher is otherwise occupied.
- Increased encouragement and support from TA's can benefit the social wellbeing of learners.
- Help share the workload of teachers, thereby reducing teacher stress.
- Can cater for small groups.
- Can continue with stronger learners when well-prepared, while the teacher provides support to weaker learners.
- Can increase the quality of the instruction and education of learners.
- Can help maintain classroom discipline, especially in large classes.

Cassim and Moen (2020, p. 4) write that little is known about TA's employment in South Africa. Currently, the Department of Basic Education (DBE) is employing TA's in a general capacity on a short-term basis; employment has been from November to March 2020 and will be so again in 2021. This is not ideal and is likely to inflate governmental jobs, creating numbers in the short-term. Owing to COVID-19, TA's are temporarily employed using funds from suspended government services. TA's working for the DBE earn R3500 – R5000 per month. This is not in line with the United Nations Sustainable Development Goal (UN SDG) 8: Promote sustained, inclusive, and sustainable economic growth, full and productive employment and decent work for all (United Nations, 2015, p. 21). Since the DBE employs TA's for only 5 months and does not have specific tasks and training or outcomes for their employment, it cannot be called full and productive. It might result in TA's working an hour during the school day, performing menial and routine work. Teachers may be reluctant to train and mentor TA's as their employment is short-term and temporary.

The SEDC the researcher works for aims to: Support teachers, create opportunities and to have fun (with mathematics). Teachers are supported

through small group activities provided by the SEDC and TA's to assist in the activities. Teachers have been assisted with SEDC substitutes due to illness and have received training and support when needed. Opportunities are created for learners to receive better quality mathematics instruction. SEDC TA's are studying tertiary courses and this will also create future opportunities for them. TA's have received various professional growth sessions, including camps and seminars, and employability training through workshops. Fun is created by hosting competitions and challenges for learners, often with prizes for the best achieving teams. Besides the company slogans, there are also several of the United Nations Sustainable Development Goals (UN SDG) the SEDC strives towards; they include:

- UN SDG 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all (United Nations, 2015, p. 19). The role the SEDC plays in mathematics support from Gr R – 12 and tertiary studies, supports this goal for learners, teachers and TA's. The SEDC aids in completing free basic education with learners being helped with literacy, numeracy, and digital literacy, in order to gain access to further education.
- UN SDG 1: End poverty in all its forms everywhere (United Nations, 2015, p. 17). By operating in low socio-economic areas, the SEDC provides income to TA's and local businesses and creates opportunities for local communities that could enable them to break free from the poverty cycle.
- UN SDG 5: Achieve gender equality and empower all woman and girls (United Nations, 2015, p. 20). More than half of learners in Gr. 12 will be girls and ensuring their continued interest in science, technology, and mathematics aids in this goal. Three-quarters of the SEDC team is female and we continue to develop their leadership abilities.
- UN SDG 8: Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all (United Nations, 2015, p. 21). The SEDC commits to pay for the TA's studies while they are employed and provides support for their studies through personality and work assessments and an advisor to monitor and support the progress they make towards a degree; this is usually a four-to-six-year commitment on the SEDC's behalf.
- UN SDG 17: Strengthen the means of implementation and revitalise the global partnership for sustainable development (United Nations,

2015, p. 28). Creating partnerships between global clean energy companies, local authorities, local government, and local communities to reach the above-mentioned goals is another purpose of the SEDC, besides improving mathematics education.

2.9 Teacher roles

The seven collective roles of teachers for South African schools are described as follows (DHET, 2010, p. 51):

1. Specialist in a subject discipline, phase or practice;

2. Learning mediator;

3. Designer and interpreter of learning materials and programmes;

4. Leader, manager, and administrator;

5. Scholar, lifelong learner, and researcher;

6. Assessor, and

7. Community, pastoral role, and citizenship.

The above seven roles are important to keep in mind as these are the roles the TA's should support teachers with. Moreover, the TA's themselves will become teachers in the future and then these roles will be required of them. When doing workplace based training, one should be aware of what is required in the workplace.

2.10 Teacher Assistant roles

Since one of the goals of the SEDC project is to create more quality teachers (and not just temporary TA's) in the communities we serve, the basic competencies of beginner teachers should also apply to our TA's. The DHET (2010, p. 52) reminds us of the basic competencies of a beginner teachers. Newly qualified teachers must:

1. Have comprehensive subject knowledge.

2. Know how to impart their subject(s), how to sequence, pace and select content according to learner needs and the subject.

3. Know who their learners are, how they learn, recognise their individual needs, and therefore adapt their teaching consequently.

4. Know how to communicate effectively, generally and within their subject, so as to mediate learning.

5. Have well developed numeracy, literacy, and IT skills.

6. Have knowledge of the curriculum, be able to unpack the specialised content therein, and use available resources fittingly, so they can design and plan appropriate learning programmes.

7. Understand diversity, so as to teach in a manner that includes every learner, identify social or learning problems, and collaborate with professional services to ameliorate the problems.

8. Create a favourable learning environment and thus be able to manage diverse classrooms efficiently.

9. Use assessment results to develop teaching and learning, and be able to use varied and reliable assessments.

10. Have a constructive work ethic, display good values, and conduct themselves appropriately to develop the teaching profession.

11. Reflect critically on their own practice within their professional community, in theoretically informed ways, so as to constantly progress and adjust their practice to changing circumstances.

The SEDC TA's are working towards becoming teachers themselves and keeping the above competencies in mind during their tenure at the SEDC will ensure that they keep the bigger picture in mind even when just working on a mathematics intervention.

2.11 Further roles within a community-based project.

Participatory action learning and action research (PALAR) consist of 3 R's, 3 E's and 7 C's and within these components, more roles of teachers based in community education will emerge (Zuber-Skerrit et al., 2020):

Relationships and relationship building, which underpin the development of trust, cooperation, and team building, are intrinsic to the ongoing success and sustainability of a project or programme.

Reflection (as critical, self-critical, and meta-reflection) is an essential practice in designing, implementing, learning through, and evaluating the project. Through reflecting critically on the process and their place in it, participants learn a great deal about themselves, others, and the knowledge they have co-created. They also learn to identify requirements for further action and the conceptual lessons of the process, enabling them to contribute to conceptual, as well as practical knowledge. Through

meta-reflection (reflecting upon their own reflective process/es), participants can further their own worldviews, which are valuable for all of life.

The recognition of outcomes (of both learning and research) is important as affirmation of personal and collective achievements, need to be rewarded and celebrated as such.

The 7 C's, as originally developed by Zuber-Skerritt (2012, p. 217–218):

(1) Communication, cultivated initially through relationship, vision and team-building activities at the very start of a project or programme, to ensure effective research-oriented exchange of ideas and team work throughout the project.

(2) Collaboration among all members of the group, generating team spirit, symmetrical communication and synergy.

(3) Commitment to the group, to the completion of the project, and to positive, sustainable change and development throughout the project.

(4) Coaching and learning from one another in dialogue, discussion, and by asking fresh questions that open new lines of inquiry (Action Learning).

(5) Critical and self-critical attitude and reflection on action, which also entails being open to feedback from critical friends and to new or different perspectives (Action Research).

(6) Competence in facilitating teaching and activities, using effective processes and methods, with a vision of excellence, leading to a high level of performance, thus Action Leadership.

(7) Character building because of the above, characterised by integrity; trust and being trusted; honesty; respect for others, for diversity and for difference; resilience; and an openness to new perspectives, opportunities, and innovations.

The 3 Es are: Emancipation, Empowerment and Emergence of a fairer, more just society. The SEDC teams' vision is the emancipation of the local community from the poverty cycle, the empowerment of our youth (that the SEDC team is part of) and the emergence of a more just society because of the help we provided.

2.12 Complexity of roles within the community-based project

Collecting the threads of the previous headings, it becomes clear that the research within the project is complex. The project overall aims to improve the lives of the local community through enhancing the quality of education by eventually providing high quality teachers and within this process, the research is taking place. As described above, the project falls within PALAR and to reach the goals of the project and the research objectives there are elements of action research (AR). This is the case for the preparation for the TA's, where their number sense was evaluated. After number sense was deemed to be sufficient, the process of improving the learners' number sense was collaboratively approached through participatory action research (PAR). Through these processes the whole team had to grow to meet the research (and project) objectives and this process entailed action leadership (AL).

The complexity of the roles was a challenge and these challenges and the solutions to the challenges will be described further in the next chapter, together with how the methodology and paradigms overlapped and changed during the research

CHAPTER 3: RESEARCH METHODOLOGY

3.1 INTRODUCTION

The research methodology was guided by the intersection of the paradigm, research approach, research design, and the chosen research tools that are appropriate to fulfil the objectives of the study (Creswell & Creswell, 2014, p. 35).

Research methodology places research in paradigms and within these paradigms there are various scientific methods to be followed to ensure that the research is valid and reliable (Creswell & Creswell, 2014, p. 41). This chapter will document the journey of the researcher and subsequently the participants and how circumstances necessitated changes in the researcher and assistants' initial views and intended methods of conducting research.

3.2 RESEARCH PARADIGM

Paradigms are generally placed within four categories: post-positivist, constructivist or interpretive, transformative and pragmatic. The latter two paradigms offer the most relevance to the project wherein the research takes place, and the problem addressed within the research, respectively. The intersection of these paradigms has shaped the research and ultimately led to the mixed methods design.

While investigating paradigms suitable for the research, two points from post-positivism stood out (Creswell & Creswell, 2014, p. 37). First, that knowledge is shaped by data, evidence, and rational considerations, where data are collected through instruments and or observations. Second, competent inquiry must examine bias and be reliable and valid. Furthermore, in this study it became evident that if an experimental or quasi-experimental design should be used, that there would have to be some kind of control for the data to be deemed valid and reliable.

The constructivist worldview elucidates that people make meaning from the world they engage with and that meaning always has a social and historical perspective influenced by cultural practices (Creswell & Creswell, 2014, p. 37).

As an extension of, or even a critique of the constructivist paradigm, the transformative paradigm emerged that posits that meaning is social and historically influenced. This said, there needs to be a remedy when social and historical practices have negatively affected specific groups (Creswell

& Creswell, 2014, p. 38). The terms political, critical, and radical are often associated with the transformative paradigm, which is power, justice and change orientated. The remedy, mentioned previously, is usually in the form of an action agenda which aims to help the marginalised group by envisioning reform in the institutions where the individuals live and work. Research in the constructivist paradigm is done collaboratively as not to further marginalise participants. Participants are empowered through assisting with the design of the research, the data collection, and the analysis of information and should reap some kind of reward from their efforts. TA's studying education themselves, and who participated in this study could gain experience in research practices, lesson planning, teaching methods and relevant workplace experience.

When selecting a research approach, it is crucial to consider the research problem or issue being addressed, the personal experiences of the researcher and the study's audience (Creswell & Creswell, 2014, p. 31). From these considerations, the rigid structures the above three approaches offer and the fact that most SED practitioners are self-taught, the researcher found more resonance with pragmatism. Pragmatism is associated with phrases including, consequences of actions, problem centred, pluralistic and real-world practice orientated (Creswell & Creswell, 2014, p. 36). Concerned with what works and being solution orientated, the focus is less on methods and more on the research problem; using and having the freedom to use all available approaches to understand and solve the problem. When using a pragmatic worldview, it is important to justify the mixing of methods. Pragmatists agree that research occurs in a historically influenced, social and political context; thus, it can include theoretical lenses with political and social justice aims (Creswell & Creswell, 2014, p. 41).

3.2.1 Axiology, ontology, epistemology, and methodology

In order to better grasp the paradigm, the words in the above heading need some explanation as they determine the different scientific processes that are utilised in the various paradigms. Kivunja and Kuyini (2017) offer their descriptions below:

Axiology refers to the ethical considerations that should accompany any research endeavour, especially one working with people. Fundamental to axiology is the global human right to dignity and respect, coupled with freedom of choice. Further ethical considerations would encompass more practical aspects of research relating to privacy, property, accessibility,

and accuracy. These practical aspects will be described in more detail throughout this chapter.

Ontology concerns itself with the interrogation of assumptions researchers' make to make sense of the world. These assumptions are the foundation of how researchers construct their reality and will influence how they go about elucidating meanings within the data they gather. Furthermore, the assumptions one makes will help guide one's research study, aiding in the construct of the research problem, the significance thereof and the approach. Thereby, answers to the research questions through investigations to find useful solutions, are gained (Kivunja & Kuyini, 2017, p. 27).

Epistemology is concerned with how we come about knowledge, what is truthful, and how we move from what is known to new knowledge (Kivunja & Kuyini, 2017, p. 27). The researcher's view on reality influences the research and the influence of researcher bias on any study is important to take cognisance of. When conducting research, the researchers must critically reflect on how their past and present experiences influence their view of reality and how this in turn, reflects on their interpretation of data. In order to mitigate bias, the use of a pragmatic worldview that includes different forms of data could aid in minimising bias through triangulation. The verification of data with participants after the raw data have been processed, will also help mitigate the effect of bias, where participants agree that their interpretations have been correctly captured.

Methodology is the logical, scientific, organised flow of the research process that contributes to answering the research questions and making a valid contribution to knowledge in the chosen field. Expanding on validity requires the inclusion of assumptions and limitations and how both these are addressed (Kivunja & Kuyini, 2017, p. 28).

3.3 RESEARCH APPROACH

Following the pragmatic worldview, this study utilises a mixed method approach. First, a pre-emptive action research phase determines participants' number sense and multiplication fluency. Second, a participatory action research phase is implemented to ascertain the learners' problem. A plan is devised to help learners and is then executed to improve grade four learners' number sense pertaining to multiplication.

This study will use both qualitative and quantitative research designs to conduct the research. The quantitative data served as a basis for understanding the teacher's strategies to improve number sense better.

3.4 RESEARCH DESIGN

Participatory action research is a good method to improve societal issues identified by a research team through consultation (Esau, 2013, p. 2). According to Katoppo and Sudradjat (2015, p. 122) the repeating action-reflection cycles integrate practice and theory. Phases of planning, action, observation, and reflection will be used and repeated, if necessary, to fulfill the research aims and objectives (Burns, 2009, p. 290). The planning phase precedes the action phase, to ensure actionable action. The action is to improve the Grade four learners' multiplication and number sense. Reflection ensures that there is consensus that the endeavour was successful. The ontological aspects of participatory action research will require open-mindedness towards the varying subjective viewpoints of the participants (Jacobs, 2016, p. 50). Epistemological aspects of participatory action research produces indigenous knowledge through shared perspectives and experiences (Caraballo et al., 2017, p. 311).

3.4.1 The research structure

The SEDC team started as participants determined and improved their own number sense and multiplication. Moreover, participants administered a multiplication test to Gr. 4 learners and marked these tests. Then, as co-researchers, a simplified PAR cycle was used, with the structure as follows (Owens & Wang, 1996, p. 6):

Phase 1: Framing (planning), where participants collectively decide the objectives of the Gr. 4 interventions to improve multiplication.

Phase 2: Activity, the learning activity ensues to administer interventions and make observations.

Phase 3: Reflection (Debriefing), from marked post-tests and observations, participants discuss what went wrong, what went right and what was unexpected. Reflection is used to decide on the effectiveness of the interventions.

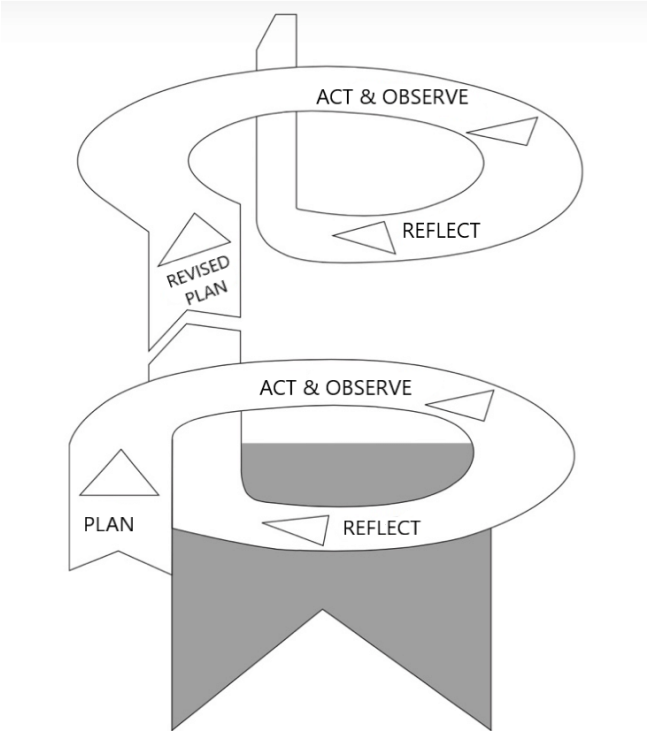

Figure 1: The action research spiral (Kemmis & McTaggart, 2007, p. 278), upward orientation by researcher

Figure 1 describes the general spiral process of action research. The researcher opted to change the orientation to an upward spiral to reflect the voluntary dive into and emergence from the problem, as well as the upward movement that may be achieved as the research led the team towards enlightenment and possible solutions to the problems faced. The co-researchers followed this structure, but rather used the terms Framing (planning), Activity and Reflection (Debriefing). It should be noted that the Pre-Test is not a cycle on its own and the Post-Test another; rather, the whole process is a cycle with the option to continue, if necessary.

Phase 1: Framing (planning)

Since the TA's are still students and not yet teachers, the researcher had to lead the planning meetings of how the participatory community-based strategy would improve Gr. 4 learners' number sense and multiplication.

Normally (pre-COVID), there would be meetings for the following week's work with small groups. During the PCBS, the interventions would be the following week's work; ten meetings became three long, safe meetings. The interventions were planned and decided upon as a group of co-researchers. All in the SEDC team were aware of the strategy that they would have to execute within a school term. The strategy started with the knowledge gained from the marked pre-tests. Thereafter, the researcher assisted the team to use the ideas that were generated from meetings, feedback forms (questionnaires), and planning meetings, and convert them into lesson plans. Once lesson plan structures were explained, the group contributed to the strategy that would be followed.

The lesson plans would follow a typical structure with introduction, body and conclusion. How these 3 parts would be conducted was discussed. An introduction would explain what the learners would learn that lesson. The body would entail the work the learners would do and how the TA would guide the learners in the planned activities. Informal assessment in either verbal or written form would conclude the lesson as the conclusion. During the planning sessions the resources that would be used during the lesson were decided on, discussed and the use thereof practised and explained. TA's were asked to inform the researcher of how their lessons went and had to observe the impact of their lessons. Correspondence would be through the social media platform, Whatsapp and email.

Phase 2: Action

Knowing what to do, with the necessary resources in hand and the schools' mathematics teachers expecting the TA's, the TA's would present the planned lessons. The action is executing the action plan, delivering the intervention as closely to the plan. During the lesson, observations would be made by the TA's and each week's progress reported to the researcher.

Phase 3: Reflection (Debriefing)

After the intervention lessons and subsequent to the marked post-tests, TA's would give feedback on the tests. Then, a decision on the effectiveness of the interventions would be drawn. Here the researcher would consider the results and feedback drawn from the TA's own experiences. Thereafter, TA's would relinquish their 'trainee teacher' and co-researcher roles and cease further multiplication interventions in this capacity. They would return to assist teachers in their mathematics

instruction activities as their allocated mathematics teacher(s) at their specific schools saw fit. The researcher would exit the PAR cycle by no longer facilitating research related meetings; instead, meetings would be project related. Moreover, no longer would the researcher be available to support TA's with intervention related problems and relinquish the role of co-researcher. They would return to the SEDC project co-ordinator, robotics event facilitator and FET after- school mathematics extra class teacher.

3.5 THE INTERVENTIONS

Introduction

The purpose of two interventions is firstly to validate the SEDC teams' own number sense and multiplication fluency. The second intervention is for the Gr. 4 learners.

3.5.1 INTERVENTIONS FOR THE SEDC TEAM

Before the intervention with the Grade 4 learners the SEDC team wrote the Ballard one minute test and a number sense test, to ensure that they were fluent in multiplication.

Concerning the preparations of the SEDC team, involving the Ballard one-minute test and the number sense test, a pre-experimental design is followed. Here, a single group without a control group, writes a pre-test, then undergoes a treatment during the experiment, followed by a post-test (Creswell & Creswell, 2014, p. 219). An intervention was deemed necessary should the SEDC team obtain an average of less than 85% for the Ballard one-minute test and below 50% for the number sense test.

Owing to the convergent nature of the study, there was no explicit intervention by the researcher after the pre-test for the one-minute Ballard test for the SEDC team. However, the post-test was administered after the SEDC team had marked the pre-tests of the Gr. 4 learners, exposing them to the test many times before the post-test. The post-test would have the numbers to be multiplied inverted. The test would therefore be the same but different, testing for the commutative property of multiplication as well.

The intervention for the number sense test (written by the SEDC team) was done after analysis of the pre-test results. Due to the time constraint of the test, suitable strategies should lead the participants to the correct answer within a minute. The researcher planned the intervention as a

group discussion and made used of a number-talks strategy. The researcher prepared as many short, effective strategies as they could think of, having at least two strategies for each question, to contribute another strategy if it were not mentioned by the group. Questions that everyone answered correctly would have the option of being skipped, if the group felt it was unnecessary to review the question.

3.5.2 INTERVENTIONS FOR THE GR. 4 LEARNERS

Interventions for the Gr. 4 learners took place on a weekly basis. After the Gr. 4 learners had written the pre-test, the results were analysed, and weekly interventions were planned. The planned interventions were a product of brainstorming sessions and suggested strategies by the SEDC team, were converted into worksheets by SEDC teachers to ensure neatness, legibility, clear instructions and appropriate spelling and grammar. TA's would administer the intervention to small classes of 18 or fewer learners after they were prepared for the intervention strategy by the SEDC teachers, in a weekly meeting. When the various weekly interventions were completed at each school, a post-test was written and marked by the TA who conducted the interventions, marks were captured on an Excel spreadsheet. The researcher did perform spot checks on the tests and used the data from the spreadsheets for further analysis of the quantitative data.

3.5.2 DATA COLLECTION

Introduction

Below, sampling and then data collecting instruments and procedures for both quantitative and qualitative data will follow.

3.5.2.1 Sampling

Convenient sampling was used for this study as the researcher had easy access to all the participants, due to his work within the SEDC. However, the work that the SEDC engages in has purposely preselected a sample of local youths and low quintile schools and learners of a rural community of a poor province, that have poor mathematics results (Creswell & Creswell, 2014, p. 239).

The benefit of selecting the whole SEDC group is that this group will be prepared for the interventions and provide their unique perspectives to help co-create interventions for the learners. The SEDC group will also aid in deciding on how effective the intervention was. The SEDC group

used the Ballard one-minute test and the number sense test to prepare themselves for the interventions and this process helped them to give valuable input in the preparation and execution of the intervention for and with the Gr. 4 learners.

The SEDC project operated in local schools and thus convenience sampling was used to select these schools. The selection of four primary schools with 412 Gr. 4 learners provides a large sample size sufficient for sample saturation to yield generalisable conclusions from this study. When considering the final selection results, learners who wrote both the pre-test and post-test were included, while learners who did not write both tests were excluded from results, it is estimated that the sample size should still be over 300 learners. The exact amount was 317 learners in the final selection.

The tests and interventions took place at each school during class time, and each session took approximately one period, or 30 minutes. The schools provided the venue for the intervention and the teachers were expected to be present during the lessons. TA's shared their planned lessons with the teachers and arranged a time to work with learners.

3.5.2.2 Data collection instruments

- **Instruments for Quantitative data (Pre- and Post-Tests)**
  - Number sense test (SEDC team)

This test was used to prepare the SEDC team for the intervention; no learners wrote this test. The test was also used to gauge the number sense of the team before the intervention. The number sense test used to gauge the SEDC teams' number sense, started out as an international number sense test for Gr. 6 learners, developed and normed by Professor Yang in 2009. This test was adapted for a Southern African context, by changing for example, standard units to metric and aligning number magnitudes to local curricula, by Courtney-Clark and Wessels for their 2014 study. The number sense test, tests for order of magnitude, fractions and comprehension of multiplication and its applications. Significant to number sense, this test also tests for mental calculations or fluency of basic operations (including multiplication) and estimation (Courtney-Clarke & Wessels, 2014, p. 4). The use of a Gr. 6 evaluative test for the SEDC team to teach Gr. 4 learners, is in line with norms and standards applied by the South African Department of Basic education, whereby the work mastered (as a mathematics teacher), is two levels

higher than the work one is to teach, e.g. teaching matric (Gr. 12) mathematics requires a teacher to have at least passed second year tertiary mathematics.

- Gr 4 Multiplication test instrument (SEDC team)

The Ballard one-minute multiplication test, tests fluency in multiplication and has been wildly used internationally, as well as locally by Dr. Benjamin for his study in 2005 and was normed and standardised by UCT. Hansen (2018) also used the test in her number sense study in 2018. This test is for the measurement of multiplication fluency for number 0-9 and is conducted in one minute.

- Gr. 4 Multiplication test instrument (Gr 4 learners)

The Ballard one-minute test was used to test grad 4 learners' number sense. However, Gr. 4 learners had 20 minutes to complete the test. The test tested multiplication fact knowledge of number 0 – 9 as prescribed in the CAPS document. The test instrument used for the post-test was the same test, but with numbers reversed, e.g. 1 × 2 would now be 2 × 1, testing for the associative law. The interventions were developed collaboratively by the SEDC team and various aims for the interventions were established, with the hope of improving Gr. 4 multiplication and number sense. Understanding the associative law for multiplication is an important indicator of number sense pertaining to multiplication (Woodard, 2006, p. 271).

- **Instruments for Qualitative data**

These instruments were designed to answer the research questions specific to the study and were not piloted, but submitted with the CTR.

- Pre-Test Feedback written questionnaire.

This instrument was answered by the co-researchers individually and featured the question of what error they had observed from marking the pre-tests, as well as how they suggested these errors could be attended to.

- Brainstorming session

The session was organised to generate possible ideas to teach Gr. 4 learners multiplication facts.

- Planning session

Detailed planning was done on how we would proceed with Gr. 4 multiplication. These plans should include lesson plans and when we would do what, for the effective teaching of multiplication facts.

- Post-test feedback form

It was a similar form to the pre-test feedback form; however, the second question was: What improvements have you seen on the Gr. 4 multiplication test that you marked?

- General feedback session

This session was to evaluate how successful the SEDC team felt the intervention was.

3.5.2.2 Procedures for data collection

Quantitative Data

Data for the number sense test (SEDC team) were collected on the day the test was written. Data as pre-test results were analysed shortly after writing the pre-test. The researcher made some observations during the intervention session. Further data were gathered on the day the post-test for the number sense was written. Data as post-test results were analysed shortly after writing the post-test.

Data for the one-minute Ballard multiplication pre-test (SEDC team) were analysed as pre-test results, shortly after the test was written. Data for the one-minute Ballard multiplication post-test were analysed as post-test results, shortly after the test was written. The two students who performed adequately to continue the intervention with the learners, but performed the worst of the SEDC group, were contacted through Whatsapp and informed of their below group average score and asked what, in their opinion, contributed to their below average score. These questions were asked after the post-test data were analysed. Students responded to these questions within a day.

Data from the Gr. 4 test instrument were collected as pre-test results. Observations from the marking of the pre-test were captured as problem areas. Possible solutions to the problems in an observed problems and solutions document accompanying the pre-test instrument, were gathered. The suggestion documents led to a meeting where possible solutions to the problems were collectively sought; some more suggestions were made at the meeting and within 3 days of the meeting,

more suggestions were sent to the researcher through Whatsapp or email. Informed by the groups' decisions and suggestions, intervention worksheets were created by the SEDC teachers. Weekly meetings and progress tracking on more and less successful intervention strategies informed the last intervention session. This was changed to include only the most successful strategies in the overview and revision intervention session.

Post-Tests were marked and results analysed shortly after they were received by the researcher. From the marked tests, certain observations could be made. The proper discussion of marked tests and the progress made by Gr. 4 learners was overshadowed by changes and continuously late monthly payments from the new electronic payment system adopted by the SEDC project sponsors. Post-Test feedback forms and reflections on the entire process was however, received from the team (after payment issues were solved.)

Qualitative Data

Pre-test feedback form

This form was sent out along with the pre-tests, and co-researchers filled in and returned the form after the Gr. 4 pre-tests were marked. Various schools wrote the tests at different times, but within the scope of a week.

Brainstorming session

The brainstorming session to generate practical, executable ideas was also subject to debate and discussion, much like a focus group. The ideas finally generated were also captured as minutes of the meeting after being repeated to the group to check for agreement and a final opportunity to contribute to the idea. The minutes were then typed from notes a few days after the meeting. Further ideas were welcomed within the duration of a week after the brainstorming session and could be sent to the researcher through email. These responses would be added to the list of actionable ideas for the intervention.

Planning session

This session was to familiarise co-researchers with the lesson plan format of introduction, body and conclusion. Here we decided what introduction, body and conclusion would entail for each of the planned interventions. This left the TA's with the knowledge of the format of the lessons and the researcher with a structure to create the worksheets.

Post-test feedback form

After the post-tests were marked the accompanying form was filled in by the individual co-researchers. Different schools completed the tests at different times, but within the scope of a week. The forms were filled in and emailed to the researcher.

General Feedback Form / Debriefing session

Individual feedback on the perceived success of the intervention from the co-researchers was sent out after the data from the post-tests were received, combined, and analysed by the researcher. At this time, the planned debriefing session did not take place, due to the understandable unhappiness from the co-researchers of late payment of their stipends caused by a new payment system error.

3.6 RELIABILITY AND VALIDITY

Reliability and validity are not interchangeable terms and differ in meaning across quantitative and qualitative research. Qualitative validity means the research checks the accuracy of the finding using certain procedures; qualitative reliability means the researcher's approach entails consistency across differing projects and researchers (Creswell & Creswell, 2014).

Strategies to increase qualitative validity include: triangulation; using thick descriptions; clarifying bias; presenting discrepant or negative information; using member checking; spending a prolonged time in the field, and using peer debriefing (Creswell & Creswell, 2014, p. 251). For this study triangulation would mean using test results and other data gathered and comparing if they indicate the same result(s). Being cognisant of differences in age, culture, gender, socioeconomic origin and history, can help minimise bias. Where possible, feedback is not only dependant on the researcher, but thick descriptions can also be used to paint an accurate picture. All results are mentioned, and only likely explanations are given. Processed data will be presented to the participants for their approval on the accuracy thereof, and no intended meaning should be lost through the data analysis processes. The researcher has been part of the local community for longer than the study's duration, thus gaining better insight into local ways of doing things. Some of the work done on the study was presented at a conference for unbiased feedback from persons with no interest in the research project.

Qualitative reliability is ensured by carefully checking transcripts for errors and making sure there is no drift in the meaning of the codes (Creswell & Creswell, 2014, p. 252).

3.7 ETHICAL CONSIDERATIONS

Complications due to COVID-19

Owing to safety concerns and agreed upon conditions for research permission with the Northern Cape Department of Basic Education, as well as work obligations under the new work model where the researcher was engaged in FET tuition, observations as initially planned could not take place. Feedback from students on their progress with the interventions was received and monitored through email, WhatsApp, phone conversations and diary entries or notes.

3.7.1 Ethical Clearance

The following institutions were contacted for permission to conduct the research:

- University of the Free State's General/Human Research Ethics Committee: I applied for ethical clearance and the UFS GHREC approved the ethical clearance application (see Appendix A).
- Department of Basic Education – Northern Cape, Pixley ka Seme District: I requested approval to conduct research in the Department of Basic Education, Northern Cape Province and the approval to conduct research was received (see Appendices B and D).
- Local schools**:** I applied to four schools requesting permission to conduct research with teachers, research assistance, and learners, and approval was received (see appendices C). Permission letters were received and submitted to the ethics committee. The letters are not attached due to anonymity concerns.

3.7.2 Informed Consent

The participants in the study, teachers, and teacher assistants signed the consent forms after the research process was explained to them. Parents or guardians were asked to sign the consent forms on behalf of the learners. Other information will be found in the appendix on informed consent.

3.7.3 Learner consent and parental assent

Guidelines from Creswell and Creswell (2014) and the University of the Free State's ethics committee pertaining to research involving children, were followed. A simplified version of the normal research consent form was discussed with all learners before they wrote the tests (see Appendix F). Learners signed for consent on the consent slip printed on the back of the tests (see Appendix I). The learners (and parents) were informed that their participation is voluntary and that their names and marks would not be made public. The schools sent letters to the parents informing them of the research; parents signed permission slips for their children to participate. Discussions with the learners clearly stated that the research was not on them, but with them and that their participation in this study could help them improve their multiplication. The emphasis was that learners were helping the SEDC team to better understand how to teach multiplication and to help teachers and improve learners with mathematics.

3.7.4 Confidentiality and anonymity

Every aspect of research should have an underlying thread of ethical conduct. The assurance of confidentiality and anonymity is central to putting research participants at ease. Following this assurance, participants can be recruited to help reach the aims and objectives of the study. Anonymity and confidentiality create a safe space for learners and TA's to freely and openly participate in the tests, interventions, and analysis of the data gathered. Learners and TA's were made aware that no-one who does not absolutely have to know, will not know their marks and or responses, unless they themselves tell other people. Participants were thus made aware that they were also responsible for the confidentiality and anonymity of their data.

3.7.5 Protection from harm

Learners were made aware that the tests and interventions they would participate in were for their mathematical enrichment, and would not negatively affect their schooling. TA's were also made aware that their performance in the tests and participation in the research, would in no way negatively influence their position within the project.

3.8 CONCLUSION

This chapter elaborated on the methodology and research design used. The phases of framing, action and debriefing were explained. The ethical

considerations to gather data were also explained. In the following chapter the analysis of the data will follow.

CHAPTER 4: DATA ANALYSIS, INTERPRETATION AND PRESENTATION

4.1 INTRODUCTION

This chapter will explain how the data were analysed, interpreted and how they are presented, starting with the motivation and a signpost to summarise the analysis process. Thereafter, the interpretation and presentation will follow.

A synopsis of the process is presented, in order to orientate the reader as to the proceedings of the study and the subsequent data analyses. To prepare ourselves for the Gr. 4 multiplication tests and interventions, the SEDC team (1 teacher and TA's) wrote both the Gr. 4 multiplication test and a Gr. 6 number sense test. The outcomes of the preparation will be discussed in a separate paper; hence, the team entered the study knowledgeable about number sense and able to multiply well.

The data gathering process started with Pre-Tests that were written by the Gr. 4 learners and marked by the SEDC team. The test was multiplication problems from 0-9. Observed errors were reported, leading to a frequency table for the Pre-Test. Then, written and verbal suggestions for correcting these errors led to a meeting resulting in an intervention plan.

The intervention plan was executed, and a Post-Test (like the Pre-Test), was written and marked by the SEDC team. Post-Test feedback resulted in a Post-Test feedback frequency table on the test after the intervention. Marks from the various schools were analysed individually and in combination to yield graphs and tables. General feedback on the entire process from the 11 SEDC students that performed the interventions, resulted in reflection that led to codes, categories, and themes.

In these mixed methods approach quantitative data is subject to statistical and inferential analyses. Qualitative data, through the process of content analysis, led to themes. The researcher then used all the data sources mentioned above and eventually combined them to triangulate the various results to answer the research questions. In conclusion, the way the SEDC team used the PCBS was effective in effecting a positive change in Gr. 4 multiplication.

Pre- and Post-Tests, Pre-Test feedback questionnaires, Post-Test feedback, general feedback and reflections on the intervention contributed to the sources of knowledge for analysis. Generally, analysis

moves from the general to the specific to answer the research questions. General analysis steps include preparing and organising the data, developing codes and themes, representing data in tables, and interpreting the findings (Creswell & Creswell, 2014, p. 260). Though a plethora of analysis techniques were investigated, the best technique for this study was content analysis.

Data analysis

4.1.1 Motivation

Data provided a measure of usefulness of the strategy, as well as ways the strategy was used. Quantitative data came from the Gr. 4 multiplication tests written by the 317 Gr. 4 learners. Qualitative data came from the 11 co-researchers that formulated and executed the strategy.

Quantitative data from the Gr. 4 multiplication tests were analysed descriptively and inferentially to answer the hypothesis, while data from discussion forums and reflection sessions were analysed narratively, thus complementing the results from the Gr. 4 multiplication tests. The qualitative data from the co-researchers aimed to answer the research question of what knowledge was used to address the problem. Quantitative data from the learners' results were used to evaluate whether the approach used was successful or not. Qualitative data from the co-researchers provided answers as to how the strategy the team used to teach multiplication to Gr. 4 learners was employed.

4.1.2 Interpretation of the data

First, the results from the Gr. 4 multiplication tests will be interpreted by starting with the quantitative data, which are presented in the form of Tables 1 to 4 below. Each table is interpreted in the form of numbers.

Second, the data from narrative analysis were categorised into themes. The themes were presented with their categories to make sense of the words said by the co-researchers.

4.1.3 Processing of the data

The processing of the data was split into two parts; first, the quantitative data and then the qualitative data.

Quantitative data were analysed using Excel version 2205 software to corroborate quantitative data. Averages, graphs, means, standard deviation and reliability analyses emanated from these data. The number

of participants for this part of the study was more than 400 Gr. 4 learners whose data were processed into tables with numbers that required presentation.

Qualitative data

When analysing qualitative data, the starting point is open coding, then moving to inferential coding, also known as patterns coding or axial coding. Axial coding is part of qualitative data analysis which eventually leads to themes (Maree, 2016). The coding process was guided by Krippendorff (2004, p. 129) where six steps are laid out:

1. A researcher with a general and practical knowledge of mathematics and the research writings in that field, suggests questions that could be answered.

2. Once these essentially a priori dimensions are set up, they are ruthlessly scrutinised.

3. Thereafter, when these dimensions are applied to the data, some deleting, modification or adding new dimensions can occur.

4. Then, tightening up of categories to enhance mutual exclusiveness and exhaustiveness is done.

5. Pre-testing now occurs to ensure that codes are frequent enough. Moreover, categories do not overlap. Furthermore, dimensions are unambiguous, to allow for accurate coding placement. Last, exclusivity and exhaustiveness should be ensured for the ranges of responses.

6. After pre-testing demonstrates that themes and categories are clear and refined, they are settled on as final.

Qualitative data were gathered and analyses were done from the interactions of the SEDC teachers and TAs through various instruments. Therefore, the SEDC teachers and TAs will be referred to as the SEDC team, i.e., the SEDC team used brainstorming to generate ideas for the PCBS.

4.2 THE RESEARCH QUESTIONS

Main research question:

How can a participatory community-based strategy improve Grade 4 learners' number sense in multiplication?

Secondary research questions:

- What knowledge is needed by SEDC teachers and assistants to meaningfully teach Grade 4 multiplication facts, using a participatory community-based strategy?

- How can the use of a participatory community-based strategy by SEDC teachers and assistants improve Grade 4 multiplication facts of learners?

4.2.1 Quantitative Data Presentation

4.2.1.1 Data Presentation Process

Quantitative data were subject to descriptive and inferential analysis. Pre-tests and post-tests that yield data for statistical and inferential analysis, can be represented as graphs or tables. Statistical data analyses lend itself to hypotheses and therefore they are:

- H_0 = There will be no significant difference in marks from Pre-Test to Post-Test after the PCBS was used to administer a multiplication intervention.
- H_1 = There will be an increase in marks from Pre-Test to Post-Test after the PCBS was used to administer a multiplication intervention.

The null hypothesis states that there will be no improvement and the alternative hypothesis states there will be an improvement in Gr. 4 marks.

Table 1: Average percentages from Pre-Test to Post-Test for individual schools.

Site	Pre-Test Average Percentage	Post-Test Average Percentage	Difference Percentage
School 1	36,80	61,73	+24,94
School 2	23,39	43,49	+20,10
School 3	32,27	51,40	+19,13
School 4	30,64	50,49	+19,85

The four low quintile schools in Table 1 above, were from the same location in the same town; they all had a huge majority of coloured learners and all used Afrikaans as the language of instruction.

As can be seen from the Table 1 above, School 1 had the largest increase from Pre-Test to Post-Test average. School 1 is the smallest school of the samples and had only two Gr. 4 classes with 35 respondents. The TA

placed at School 1 was also one of the more senior TA's on the team, and had more theoretical, pedagogical knowledge from her B.Ed. studies and more work experience within the project setting. Besides the pedagogue, these data could perhaps suggest that learners starting with more multiplication knowledge, gained the most from the intervention.

School 2 had the lowest average percentages for the Pre-Test, and this suggests that the learners of this school had the least amount of multiplication knowledge of the cohort. After the intervention, the Post-Test average percentage was 20, 10% higher; thus, the second biggest increase. However, this school still had the lowest multiplication knowledge of the Gr. 4 group. The difference in percentage that the intervention made, was the second highest of the cohort. Therefore, in contrast with the postulate from School 1 as discussed above, learners with little multiplication knowledge can also gain an increase in test results. School two was the biggest school of the four schools, with four classes and 116 respondents.

School 3 had the second highest Pre-Test average and the second highest Post-Test average percentage. The increase was third highest amongst the cohort. This school had three classes and 77 respondents.
School 4 had the second lowest Pre-Test average percentage and the second lowest Post-Test average percentage, with the least amount of increase. Although the increase was the least, it was not dramatically different from the other schools. This school had three classes and 89 respondents.

See table below for further discussion of the entire sample group.

Table 2: Statistical analysis of the Gr. 4 multiplication test

Grade 4 Multiplication Test		
	Pre-Test	Post-Test
Mean percentage	29,14	49,20
Mean out of 33	9,62	16,24
Standard Deviation	9,22	9,50
p-value	0,000000000000000000000000000000000000000000040	

Table 2 above gives a statistical summary of the entire Gr. 4 cluster, i.e., the combined data from the four schools. The numbers and what they could mean are interpreted below.
There was a high standard deviation of 9, 22 for the Pre-Test and this deviation remained high at 9, 50 for the Post-Test. Moreover, the high

standard deviation could indicate a wide variety of cognitive developmental stages or abilities. However, the increase in test scores indicate that all learners of all cognitive developmental stages had some increase in marks. The very small p-value was also an indication that the increase was likely due to the interventions that the Gr. 4 learners received. However, due to the purpose of the study – improving Gr. 4 multiplication in a way conducive to number sense development – and the means the study used to bring about this change – through a Participatory Community-based Strategy – no one involved in the study would claim the results were exclusively due to their sole intervention. As an example, who was responsible for the Gr. 4 girl who went from 11 marks in the Pre-Test to 33 marks in the Post-Test? Some spot checking of results did occur, and the researcher was told by the TA that they gave her the test again and she attained 32 marks. She said her father helped her with her times tables. Besides the awesome father, did the actions of the TA or classroom teacher, or previous encounters with the SEDC team, encourage this positive outcome? Thus, through participation of, and collaboration with, the wider community, a positive result is more likely.

The mean score of 9,62 marks or 29,14% suggests that multiplication knowledge was poor at the time of the Pre-Test. Likewise, the mean score of 16,24 marks or 49,20% suggests that, although not stellar, the multiplication knowledge of the Gr. 4 cohort was 20,06% higher than it was before the intervention. The PCBS seems effective in increasing basic multiplication facts knowledge. Therefore, by working together (using the PCBS correctly), everyone helps everyone to grow.

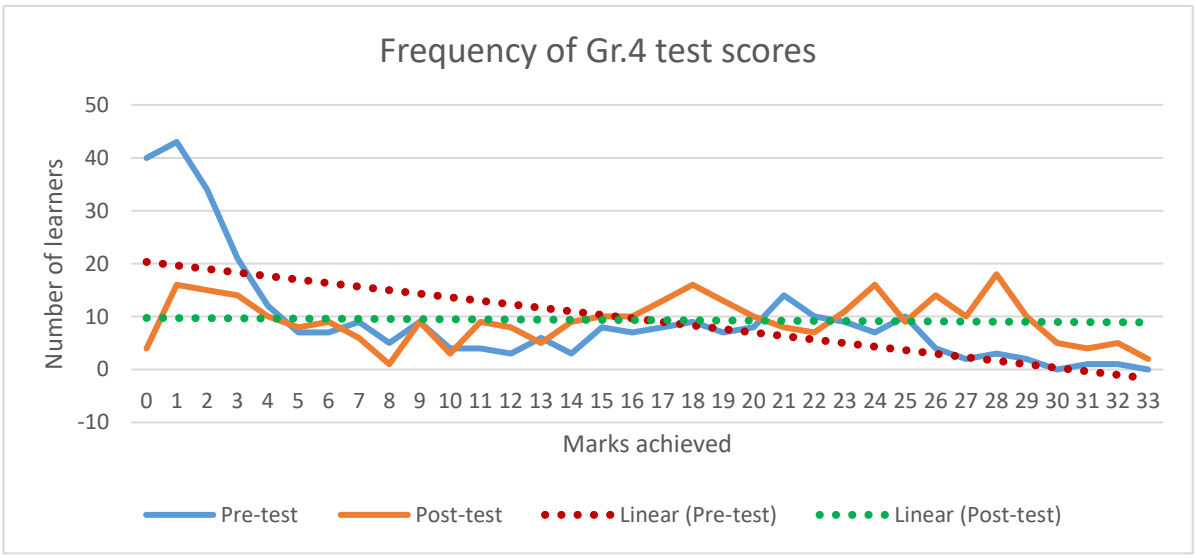

Figure 2: Frequency graph with trend lines of marks achieved from Pre-Test to Post-Test across the Gr. 4 population

From Figure 2 above, the presentation of data focused on the changes in scores of the four schools (12 classes). It can be observed from the graph, indicated in blue, that there was a high number of learners, 40 out of 317, that achieved zero marks out of 33 in the Pre-Test. Then, it should be noted, indicated in orange, that the number of learners who achieved zero in the Post-Test, was four. A deduction can be made that some attention had to be paid to the learners that attained zero for the numbers to reduce in this way.

The decline in the number of learners who achieved one, two, three or four marks was also noticeably lower from the Pre-Test to the Post-Test. Furthermore, there was an increase in the number of learners who achieved about 50% for the test and a larger number of learners who achieved better marks at the last third of the marks scale, i.e. more learners got 23 or more marks in the Post-Test than in the Pre-Test.

Looking at Post-Test scores, the following can be seen. It was calculated that for the Pre-Test, 191 learners out of the 317 achieved below 30% for the test. Similarly, for the Post-Test, the number of learners who achieved below 30% was 95. Assuming failure is set at below 30%, that would mean 60% of learners failed the Pre-Test compared to 30% that failed the Post-Test. Moreover, taking into account learners who got more than 70% (or 69) on the Pre-Test was 12,3%, and for the Post-Test the number of learners was 32,8%, it resulted in an increase of 20,5% in top achievers. Overall, there is a decline of learners who achieved very low scores; most learners did better in the midrange marks and more achieved higher marks at the high end of the mark spectrum. Therefore, this again suggested in more detail, that the PCBS was effective in bringing about an increase in marks across all ability groups. In other words, all ability groups received some effective help during the intervention.

Means and what they mean: when considering that many learners fall below the initial mean of 9, 62 marks and the Post-Test mean of 16, 24, one must consider several factors. Firstly, Gr. 4 learners are in the second term of their 12 terms in the intermediate phase, where they are expected to master times tables to 12-times. The CAPS document recommends coverage to 9-times by June. First, time with new work might be needed to consolidate newly learnt material. Second, this study was conducted in low quintile schools, where classes are large, pre-schooling a rarity, and alcohol abuse and foetal-alcohol syndrome might affect many learners. Third, because of the first two factors, many teachers struggle with curriculum completion, and this has a spill-over effect into new grades and

phases, where teachers have to complete curricula in order to proceed with the new work. Mental mathematics is recommended as a 10-minute verbal exercise for which there is no evidence required. However, there is a heavy administrative duty on teachers, and in the case of mathematics, a maths workbook, red workbook, a topic specific investigation and a remedial plan is required as evidence. Therefore, mental calculation time might be spent on the afore-mentioned required evidence to avoid being sent on a course that will further diminish available teaching time. In conclusion, even though the means are low, there is evidence that learners improved. Moreover, the PCBS can fulfill the role of mental calculation teaching time, serve as recorded remedial strategy (with proof), and give teachers time to catch up on their administration, since a TA will conduct the intervention.

Figure 2 above denotes the linear trend lines of the Pre-Test, dotted red line, and Post-Test, dotted green line, specifically. It is noticeable that the red trend line steeply declines and the green line declines very slightly. When a linear trend line is used, the gradient of the line indicates the rate of an increase or decrease. What the red line suggests is that there is a high number of learners performing poorly and a low number of learners who performed well in the test. The green line suggests there was a steady number of learners achieving marks across the spectrum.

The intersection of the lines at about 16 marks shows that for the Pre-Test more learners achieved below 16 than did for the Post-test. Similarly, after 16 marks, the green line is above the red line, indicating more learners performed better (achieved more than 16 marks) for the Post-Test than for the Pre-test. The green and red lines are farthest apart at the beginning of the graph and at the end, i.e., 1- 4 marks and 29 – 33 marks, which denotes that the greatest discrepancy between them would be found here. Therefore, in the Pre-Test a lot of learners would achieve low marks and very few high marks, whereas for the Post-Test there were learners that performed poorly. This said, almost the same number were expected to perform well.

Concluding the quantitative analysis, a reminder of the above aspects was given. The intervention yielded a statistically significant improvement. Learners across the spectrum of abilities performed better. This means the SEDC team had knowledge of their learners and knew how to interact with them in a meaningful way and were able to function well in the schools to bring about positive change. Taking all the above information from Table 2 and Figure 3 into account, the null hypothesis was rejected,

and the alternative hypothesis accepted. There was an increase in marks from Pre-Test to Post-Test, after the PCBS was used to administer a multiplication intervention. Overall, an average increase of 20, 06% was achieved across all the sampled Gr. 4 learners. Moreover, corroborating the quantitative data was the start of the qualitative analysis of the Post-Test Feedback form.

The following Qualitative data were analysed through content analysis of the Pre-Test and Post-Test to corroborate the quantitative data. After the intervention, and the Post-Test had been written and marked, TA's provided feedback through the Post-Test feedback form. Post-Test voluntary general feedback from the observations by the TA's was subjected to content analysis and yielded data as frequencies on the progress or lack thereof the Gr. 4 learners made, after receiving the multiplication interventions. The elements identified were like the Pre-Test, with the addition of less stressed. After member checking occurred, these validated elements and their frequencies are presented in a table. Below is the table with data from the Post-Test.

Table 3: Post-Test frequency table of observations after the interventions

Post Test Feedback	
Observation/Problem	**Frequency**
Large multiples (6 7 8 9) improved	11
Marks (Multiplication) improved	9
Multiplying by 0 Improved	3
Methods Improved	3
Strategy Improved	3
Less stressed	1

Since content analysis analyses qualitative data in a statistical or quantitative way through providing frequencies. Higher frequencies of responses indicate these issues raised were of general importance to more of the members of the PCBS. The objectives of the study were to improve Gr. 4 learners' number sense and multiplication by using a PCBS. The PCBS used a Pre-Test, and a plan was devised and executed and from Table 5 above, it can be seen that multiplication, including the larger multiplicands, which had improved, were the most frequent response to the observations from marking the Post-Test, as reported by the TA's. Multiplication by zero, improved methods and strategies used by learners was also frequently mentioned. The response that the learners seemed less stressed during the Post-Test was mentioned only once, but it is

significant to the role emotion plays in the acquisition of number sense (Boaler, 2015; Hansen, 2019; Schoonen, 2016). Considering that the TA's were not researchers or experts in number sense, it is salutary to see the inclusion of the recognition of the stress level of learners.

Based on the feedback provided by the TAs in Table 3, suggests that the PCBS is effective in improving the identified elements from the Pre-Test to the Post-Test. Moreover, in section 4.2.1.1 above, there was a statistically significant difference achieved from Pre-Test to Post-Test. Therefore, the PCBS had a positive effect on improving multiplication, including large multiples. Furthermore, multiplication by zero also improved, due to the intervention by using the PCBS. Improved methods and strategies, as well as a reduction in learner stress can be attributed to the use of the PBCS. Thus, the PCBS seems effective to meet the objectives to improve Gr. 4 learners' number sense and multiplication. This concludes the quantitative data; the procedure for further processing of more qualitative data will follow.

4.2.2 Qualitative Data Presentation

Data from the elven co-researchers that provided feedback for the qualitative analysis were processed by the researcher, using the steps described below, see Figure 3. The data were analysed and led to codes, categories, and themes, and a small sample size may lend itself to manual coding. The words from the research instruments may be organised into categories and themes to be presented. Moreover, the coding ultimately used was theming data, where certain phrases to describe data were then assigned a meaning; in this case, recurring ideas were grouped in a category (Krippendorff, 2004, p. 35). Dimensions and themes were used interchangeably, depending on the source. The signpost below for the steps in coding that leads to codes, categories, and themes should be noted. Please see the signpost on the next page.

Signpost

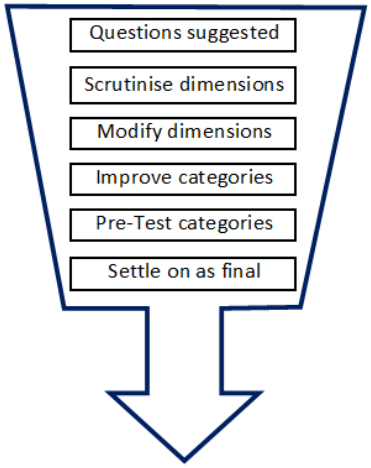

Figure 3: Steps to code (Krippendorff, 2004, p. 130)

Data from the Pre-Test feedback, focus group, discussions of lessons, general feedback on the intervention, and the reflections of the term's work were subjected to the coding process as guided by Krippendorff (2004, p. 129):

1. Questions that could answer the research questions pertaining to the objectives of the study, i.e., using a PCBS to improve Gr. 4 number sense and how this goal could be achieved served as the codes.

2. Initially two, a priori questions were put in place.

3. Thereafter, these questions were applied to the data, where some deleting, modification and adding a new question occurred. The general code was added to accommodate unanticipated, but relevant information.

4. Categories were then created from frequently mentioned responses. The categories were interrogated until mutual exclusiveness and exhaustiveness were reached. Categories must be specific, yet broad enough to represent all the data.

5. Pre-testing happened where frequent responses were shortened and combined, then placed in categories. After categories were broad and specific enough, themes were sought to group the categories. The interconnectedness of the research questions and the other emergent code made one overarching theme possible.

6. After pre-testing demonstrated that categories and themes were clear and refined, they were settled on as final.

A description of how the categories in Table 4 below came to be, will follow. First, the question pertaining to knowledge will be addressed. Thereafter, the second question will be addressed, followed by the general category and then the interconnected theme will be explained.

Data from the general feedback on the intervention led to the addition of the general category. Data from this instrument featured how well the intervention worked and that TAs grew personally and professionally. Furthermore, there was a higher frequency than normal for classroom discipline and unexpected changes that the TAs had to face.

Data to answer the research questions came from the interventions' planning sessions that were attended by the SEDC teachers and TAs, to collaborate and finalise the strategy most suitable for the milieu of the project. The planning sessions included brainstorming improvement ideas. Thereafter, ideas from the brainstorming session were discussed and the sequence of items to cover, were decided upon. This resulted in the PCBS intervention plan, see Table 3 below. With the plan in place, lesson planning was done to ensure proper instruction to the Gr. 4 learners. All participants attended the planning phase meetings, now as co-researchers. The researcher presented the planning meetings. The teacher assistants together with the researcher, discussed and agreed upon the items to focus on in class during the process of teaching and learning. Some photographs of the planning sessions' outcomes on a whiteboard served as data to represent a summary of the meetings. The planning sessions culminated in an intervention strategy with various steps and lessons co-created by the SEDC team. This team scaffolded the new knowledge on prior knowledge the learners possessed. The PCBS intervention table was created from the group interactions by the researcher and it summarises the data.

Table 4: PCBS intervention summary

	Action	Reason
Topic 1	Overview of test questions intervention	Demonstrate multiplication by zero. Strengthen concept of commutative rule.
Topic 2	Various representations intervention	Demonstrate various representations, including real world examples of multiples.

		Introduce the squared representation.
Topic 3	Squares plus one multiple more or one multiple less intervention	Familiarise learners with squared numbers to act as beacon for estimating answers and to help calculate answers near squared numbers. Improve learners' strategic competence.
Topic 4	Area representations and "Tetris"	Represent multiples as square or rectangular shapes with length and breadth on a provided grid. Demonstrate the associative rule of multiplication. Problem solve and strategise, and plan fitting shapes together to form a rectangle with no gaps.
Topic 5	Seven times multiplication and tic-tac-toe	Familiarise learners with the multiples of the seven times table and have some fun doing so. Present a different strategy to find answers to 7 x 7, 7 x 6 and 7 x 8, covered in the squared multiples intervention. Review of the seven times table.
Topic 6	4 + 4 = 8 intervention	Familiarise learners with the multiples of the eight times table. Present a different strategy to find answers to 8 x 7, 8 x 8 and 8 x 9 covered in the squared multiples intervention. Review of the eight times table.
Topic 7	Nine times table's patterns and fingers method intervention	Familiarise learners with the multiples of the nine times table. Present a different strategy to find answers to 8 x 9, 9 x 9 and 9 x 10

		covered in the squared multiples intervention. Review of the nine times table. For the fingers method, it is hoped that kinaesthetic learners might relate to it. The finger method requires no writing and presents the answer as it is written.
Topic 8	Revision intervention	To revise strategies learnt and to remind learners to plan for their test ahead by, for example, skipping sums that would take too long for ones they could solve easier and quicker. Answer the zero multiplication sum and decide what strategy to use for the nine times table; look for and answer the five times sums.

The scope of this study's first research question concerns three parts. First, the knowledge needed to teach Gr. 4 learners multiplication; second, to promote number sense and last, a combination of the two divisions to teach multiplication for number sense. Therefore, categories were created for these aspects and data were scrutinised for fit.

The intervention plan was considered to extract the knowledge needed for multiplication teaching and teaching for number sense, as well as the combination of the two. Moreover, the intervention strategy aimed to enhance Gr. 4 learners' large multiples knowledge, improve multiplication by zero, and provide better strategies and methods to learners. Ways to make the learning fun, engaging, easier and less traumatic were kept in mind during the process. From the brainstorming instrument, to the planning of the intervention, eventually categories emerged from the group's interaction. Categories were combined to finally create the categories of:

- Conceptual comprehension and mathematical connections;
- Instructional Techniques and Participation; and
- Application and Connection to Real-Life Situations.

Further discussion of these categories will follow below with Table 5.

To answer the second research question, the following data were useful. The above insights can be used as a basis for creating strategies and interventions to help Grade 4 pupils' multiplication abilities. It is obvious that addressing the difficulties connected with multiplication in the classroom, can benefit from a combination of instructional methodologies, engagement tactics, and peer assistance. The process to answer the question of how to go about creating a suitable strategy to implement, will be given below.

The items to focus on to address the elements identified, were the commutative property of multiplication, enhancing learners' estimation skills and demonstrating patterns formed by multiples. These were deemed important by the group to enhance the multiplication and number sense of the Gr. 4 learners. To help students develop a solid foundation in mathematics, effective teaching and learning of number sense can include hands-on exercises, visual representations, and problem-solving experiences (Courtney-Clarke & Wessels, 2014). Thus, from the lesson planning and then the lesson preparation instruments, ultimately the following categories emerged from the group's interaction:

- Collaboration for improved student learning;
- Recognition of student diversity; and
- Lesson planning.

Further discussion of these categories will follow below with Table 5.

The above process was repeated many times for each question, to reduce the number of categories to a manageable number that describes what happened well. However, there were still categories left that did not fit well into either one of the initial two codes; therefore, a third general code was created to include the related but separate information. Therefore, considering the data from the General Feedback instrument, the General Code was added with the following categories:

- Classroom discipline; and
- Challenging school schedules.

Further discussion of these categories will follow below with Table 5.

The method by which the theme was decided upon, took four aspects into consideration.
First, interconnectedness: If the research questions are interconnected and target diverse elements of a larger topic, common themes are likely

to emerge. Identifying these topics can help develop a cohesive narrative for the study.
Second, topic diversity: If one's research questions are diverse and not clearly related, they may lack common themes.
Third, the research objectives: If the primary goal is to investigate several aspects of a single overarching subject, a common theme may be helpful.
Fourth, clarity and aim: Whether one utilises a single theme or separate themes for each question, it is critical that the themes match the aim of the study and assist one in making sense of the findings (Creswell & Creswell, 2014, p. 99).

The instruments that helped to develop the themes, categories, and codes will be explained. The objectives of the research were:

- to identify the knowledge needed by the SEDC team (teachers and assistants) to teach Grade 4 multiplication facts using a participatory, community-based strategy; and
- to establish how the SEDC team (teachers and assistants) use a participatory community-based strategy to teach Grade 4 multiplication facts to learners.

Various repetitive aspects in the data that emerged from the instruments mentioned below, were grouped together. The process started with the knowledge that the Gr. 4 learners lacked and how the team would address their limited knowledge, through the use of a PCBS, to improve the Gr. 4 learners' multiplication and number sense. The themes here are emergent themes and will later be merged. The qualitative data process started with brainstorming, followed by the planning of the intervention. Thereafter, lesson planning and then lesson preparation proceeded. Reflection on the Post-Test and General feedback on the intervention also yielded data.

Table 5: Codes, categories, and theme

Code	Category	Theme
1. The knowledge that is needed by SEDC team to meaningfully teach Grade 4 multiplication facts using a participatory community-based strategy	Conceptual comprehension and mathematical connections	Theme 1: Knowledge needed by SEDC team
	Instructional Techniques and Participation	
	Application and connection to life situations	
2. How the SEDC team created a participatory community-	Brainstorming improves collaboration	Theme 2: Collaborative

based strategy to improve Grade 4 learners' multiplication facts for number sense		Innovation in Teaching and Learning
	Lesson presentation	
3. General	Classroom discipline	Theme 3: Classroom organisation and Discipline
	Challenging school schedules	

The three categories under the first theme will be discussed, followed by the next three categories under the second theme. Then the third theme will be discussed to conclude Table 4 above.

Two research instruments, brainstorming, and intervention planning yielded data for the emergent Theme 1. Two research instruments, lesson planning and preparation yielded data for the emergent Theme 2. Feedback and reflection yielded data for the emergent Theme 3.

Theme 1: Knowledge needed by SEDCD team.

Three categories emerged under this theme and will be discussed below.

Category 1: Conceptual comprehension and mathematical connections

During brainstorming and lesson planning, six aspects namely, utilising concrete materials; visual representations; numerical talks; relationships and patterns; real-world situations, and the fact families that relate to conceptual comprehension and mathematical connections, were identified as central to the knowledge needed by the SEDC team to teach Gr. 4 learners number sense. The SEDC team identified these aspects in simple terms, i.e. things that would make teaching and learning multiplication better; better, in the sense of more engaging and more conducive to number sense acquisition. The researcher describes the team's insights in more academic terms.

- Utilising concrete materials

The SEDC team decided to make use of things learners could *touch* and *see*, so that the learners' learning was better than rote learning. During the planning sessions, the SEDC team mentioned that the Gr. 4 learners were young and still learning how to multiply. Scholars might say that the

learners are in the acquisition phase of number sense (Hansen, 2019). To visualise multiplication problems, commonplace things, such as buttons, sweets, or money should be used (Landsberg, 2019).

The SEDC team decided and used beans and clear plastic bank bags to aid the comprehension of multiplying by zero. This was discussed in the planning session and later in the lesson planning sessions which would include lesson presentation. What to do and how to do it was discussed. Thus, as planned in the intervention, the TA would demonstrate in class the multiplication of zero, using bags and beans, e.g., 5 x 3 uses five bags stuck on the board, filled with three beans each, yielding 15; 7 x 0 would be seven bags with zero beans, each yielding zero. The advent of COVID-19 made this lesson a demonstration, rather than having learners handle the materials themselves. This concludes the *touch* part (concrete materials). See below the *see* part (visual representations).

- Visual Representations

The SEDC team discussed in the brainstorming session and lesson planning that the Gr. 4 learners should see the sums in different ways, to help them to see multiplication as groups of things. The visual representations that were used were illustrations, i.e. laminated illustrations prepared by the SEDC team and worksheets, where learners drew their own representations. Introducing arrays as a visual representation of multiplication i.e., a 3 x 4 grid used to represent 3 x 4, will aid in the conceptual comprehension and help learners make mathematical connections (Landsberg, 2019). This was done during the planning and discussion session of what we want to do and how to do it.
At least two instances of visual representations were used by the SEDC team to demonstrate multiplication visually. As planned, all TAs would ask their learners for examples in the classroom that could represent multiples, e.g., the windows in a pane could represent 4 x 8. Furthermore, learners had the choice of filling (colouring) the blocks in the area intervention; representing 2 x 4 as a horizontal or vertical rectangle of eight shaded blocks. TAs therefore had to use their knowledge of visual representations to point out the similarities in the number of blocks, in order to facilitate an understanding of the commutative property. Moreover, TAs would hand each learner a representation i.e., a laminated picture of four rows of six carrots, and ask learners to calculate the numerical value of the representation. Various representations of the same numbers were used, i.e., four rows of six carrots and six rows of four ice-cream depictions. The TA then stuck one representation from each group, some distance apart, on the board. If the TA stuck the carrots

on the board, the learner should group the ice-creams with carrots, since they both depict 24. Learners were asked to come to the front and show the class their representation and then stick it where they think it should go. The class could agree or disagree with the placement of the illustration, i.e. is the representation placed in the correct group or not? Complementing visual representations, the use of number talks was also part of the plan, as will be discussed below.

- Number Talks

Since the introduction of Number Talks to the team, in preparation for the intervention, we have tried to incorporate numerical discussions wherever possible in our dealings with learners. During the intervention planning discussion, it was suggested that we include number talks somewhere. Later, we decided to include number talks specifically in the second intervention lesson. As an example of how TAs used Number Talks during the intervention, we return to the various representations lesson, mentioned above. Learners were asked to come to the front and show the class their representation and then stick it where they think it should go. The class could agree or disagree with the placement of the illustration representing multiples, mentioning if the placement was in the correct group or not. If there was disagreement, a learner was asked to elaborate on why they disagreed, i.e., six rows of four carrots would add up to 24 and therefore, did not belong in the 20 group, and should be placed in the 24 group. Follow-up questions could include how the representations should have been grouped to belong in the 20 group, i.e., have five rows of four carrots. As Number Talks were deemed important for the teaching and learning of multiplication by the SEDC team, so relationships and patterns were also deemed important.

- Relationships and Patterns

Relationships and patterns pertaining to this study concern the commutative property and the familiarisation of patterns formed by multiples. Pattern recognition is also a necessary part of number sense (Courtney-Clarke & Wessels, 2014).

The SEDC team formulated, planned, and used intervention lessons that used patterns to practise the multiples of 7, 8 and 9. These lessons were discussed in the lesson planning sessions. The focus was to familiarise learners with less familiar multiplication problems and ways to make the learning of these newer problems more interesting and easier than rote

learning. The game tic-tac-toe was used to show the pattern of seven's multiples. Following the seven's multiplication, was the eight's multiples, that the team dubbed the 4 + 4 = 8 intervention, also using patterns and prior knowledge. Thereafter, the multiples of nine that form an easy and familiar pattern were covered. The SEDC team had to use their knowledge of the patterns of multiplication to demonstrate it to the learners. Being more familiar with the correct answers of larger multiplication sums, could improve learners' estimation of the correctness of their answers to larger multiplication sums, another component of number sense (Courtney-Clarke & Wessels, 2014).

- Real-World Situations

The SEDC team, especially the TAs, had to use their knowledge of the local community of which they are part, to teach number sense by emphasising instances in real life where multiplication is needed. This would help learners see the usefulness of multiplication and mathematics, creating a productive disposition towards the subject (Courtney-Clarke & Wessels, 2014). The examples and explanations in the lessons and lesson introductions were presented to local learners by local teachers (TAs) to create authentic real-world situations with which the learners will resonate.

The SEDC team touched on this concept in the various representations lesson when doubling a recipe, figuring out distances and speeds, or figuring out prices and discounts. In addition, this would prompt learners to use real-life objects as examples of multiplication representations which foster mathematical connections in a tangible manner. Agreeing that it is important for learners to realise multiplication is all around us, was followed by learners knowing multiplication. They should also be made aware that they know other things related to multiplication, i.e. the fact families.

- Fact Families

The SEDC team used their knowledge of the fact families by incorporating guiding questions into the area representation intervention lesson. Fact families take the concept of the commutative property one step further by assisting pupils in understanding the connections between linked information, i.e., if you add 3 x 4, for instance, then include 4 x 3, 12 ÷ 3, and 12 ÷ 4 (Boaler, 2016). The TAs used fact families in the "Tetris" or "Area" intervention, whereby grids were shaded to represent multiples.

After the first example was shaded, a 3 x 4 grid, questions are asked about the representation. How many groups of 3 are there? Then, what would 12 ÷ 4 be? Similarly, groups of 4 could be asked.

2. Instructional Techniques and Participation:

Instructional techniques were discussed in the lesson planning sessions. The SEDC team worked together on how the lessons would be introduced and made sure that the lesson introductions had a more conversational tone, rather than a lecturing style. Moreover, the number talks content was solicited from the SEDC team to build up, practise and enhance our knowledge of instructional techniques, in this case the use of number talks in the various representations lesson. The various representations lesson would also use a hands-on activity as instructional technique. The SEDC team agreed this would be more conducive to number sense teaching than merely rote learning of times tables.

The process of laying out the format and subject matter of a lesson or class is known as lesson preparation. It is an essential component of good instruction, and includes several vital components (Landsberg, 2019, p. 398). The planning phase happened after the Pre-Test and the prescribed handbook of our senior students was used to help prepare lessons. The following principals were kept in mind during the lesson preparation sessions that included the whole SEDC team. Further discussion of how the process unfolded is in Figure 4 below.

Setting clear goals and objectives for pupils to learn by the end of the lesson is called objective setting. Goals ought to be time-bound, relevant, measurable, achievable, and specific (SMART).

Evaluation and Assessment: Deciding how the understanding and progress of the students will be evaluated during and after the class. This could entail tests, talks, assignments, or other forms of evaluation.

Content Selection: Selecting and arranging the lesson's subject matter. This entails choosing pertinent subjects, materials, and sources that complement the curriculum and educational goals.

Planning the approaches and strategies to be used when teaching the subject is known as instructional strategies. A range of techniques, including talks, debates, group projects, practical experiments, multimedia presentations, and other educational methods, may be used.

Timing and Sequence: Putting the lesson together in a sensible order and figuring out when to include each element. Setting aside time for activities, direct instruction, introduction, and summation falls under this category.

Adaptation is the process of considering the various demands and learning preferences of students and making the required changes to account for their varied backgrounds and skill levels.

Resources and Materials: Acquiring or getting ready the equipment, materials, and resources needed for the lesson. Technology, hand-outs, multimedia aids, and textbooks may all fall under this category.

Planning techniques: Actively involving students in the educational process and encouraging interest is known as engagement strategies.

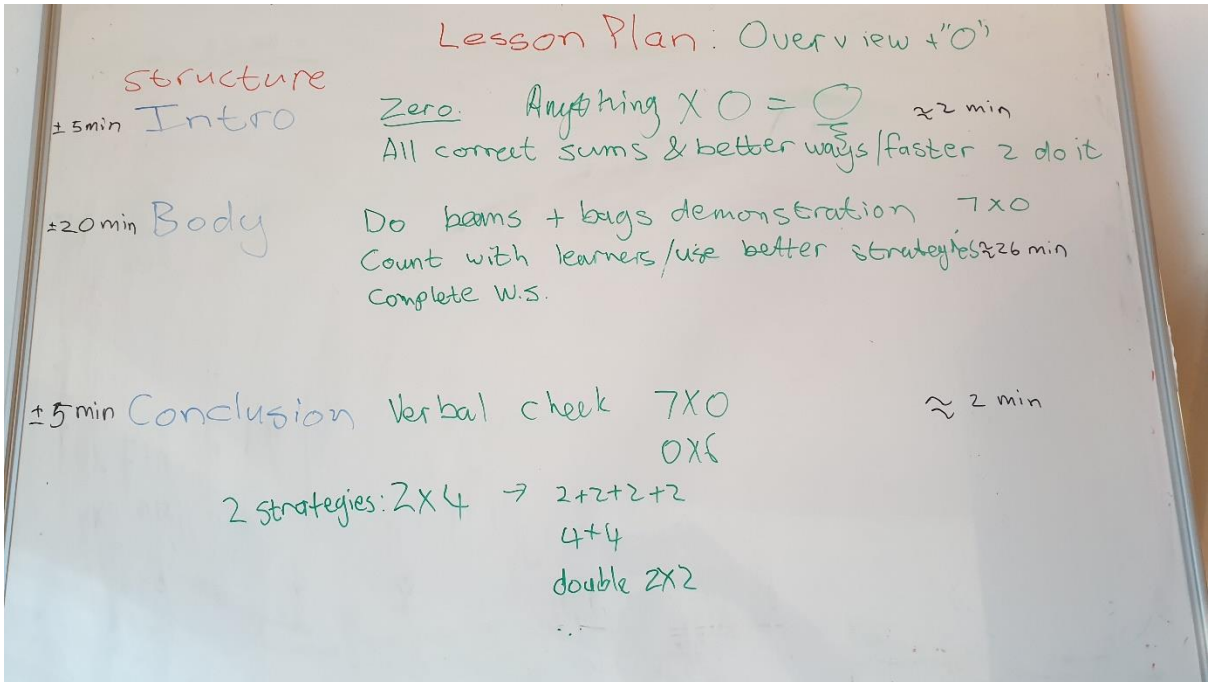

Figure 4: Lesson planning meeting, whiteboard with plan of first lesson.

Figure 4 above depicts the whiteboard, used during the lesson planning sessions involving the SEDC team. On the board to the left is the basic lesson plan structure of Introduction, Body, and Conclusion with the estimated time for each section indicated. During these sessions, the above-mentioned elements of a lesson were planned and discussed by the SEDC group members for all the lessons of the intervention. Since most of the TAs did not have experience in lesson preparation, the researcher had to take the lead in the first lesson's planning, thereafter the group supplied the details for the following seven lessons. Depicted above is the first of the lessons.

It should be noted that on the right of the board in Figure 7, are times indicated in black, because this lesson would involve a demonstration. Time for the introduction and conclusion has been shortened to allow more time in the body to accommodate the demonstration of multiplication by zero. The objective of the lesson would be to demonstrate and have learners realise that anything multiplied by zero remains zero. This objective would be evaluated by asking learners two zero multiplication sums at the conclusion of the lesson, to assess and evaluate if this understanding was reached. Lesson objectives should culminate in reaching the larger intervention's objectives. The content selected for the lesson was multiplication by zero and presenting learners with different strategies to solve various multiplication problems. Every TA had to ensure that they had the necessary resources to present the lesson, i.e., enough worksheets, beans, bags, and adhesive. This process was repeated for all the lessons of the intervention.

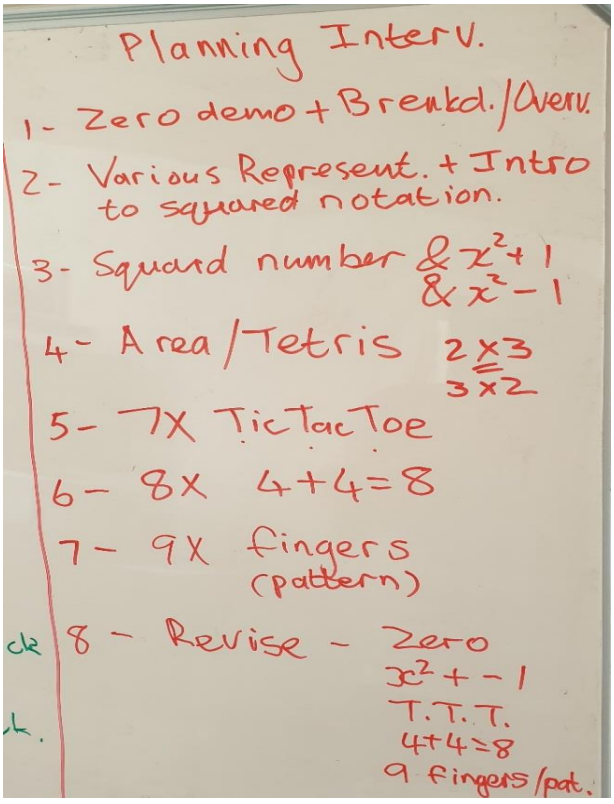

Figure 5: First outline of the PCBS

Figure 5 above denotes the first outline of the PCBS as planned by the SEDC team. From this figure, the researcher created Table 3 as in the qualitative data presentation section. This table was presented to each member of the SEDC team to create a schedule specific to their school. As part of the instructional techniques, the SEDC team had to use

knowledge of scaffolding to teach the Gr. 4 learners multiplication for number sense. From the intervention planning session, the sequence of lessons was decided. Scaffolding learning correctly reduces the frustration students' experience with learning new work and it fosters an environment where learning can happen (Schoonen, 2016). The whole PCBS is based on starting with easier and known facts and building thereupon by introducing increasingly difficult ideas. With the introduction of a new idea, the following lessons would be inclusive of the previously learnt new idea. Therefore, the first intervention introduced the commutative rule, and this new rule would be referred to throughout the intervention. Similarly, in the various representations lesson, the squared notation is introduced and in the following intervention, the squares of multiples are covered. The "4 + 4= 8" teaches the patterns formed by the multiples of eight by using familiar facts, as the name suggests.

Participation strategies were discussed in the lesson planning sessions by the SEDC team to promote and improve students' involvement and engagement in the learning process. By using these tactics, the SEDC team had to use their knowledge of participation strategies to foster a collaborative and dynamic learning atmosphere. Thereby, the students are encouraged to participate, exchange ideas, and engage with the material to foster number sense development. The SEDC teams' strategy included instructional participation, using number talks in the area lesson and a hands-on group activity for the various representations lesson. The nine times table intervention lesson purposefully included the hands/fingers method to include an activity in the lesson to enhance learner participation. In addition, the seven times table lesson incorporated the circles and crosses game, Tic-Tac-Toe. This lesson started with learners playing Tic-Tac-Toe to enhance peer interaction, another form of participation.

3. Application and Connection to Real-Life Situations:

The SEDC team discussed real-life relationships in the lesson preparation sessions to prepare them for their lesson presentations. An attempt was made to emphasise instances in real life where multiplication is needed, as when doubling a recipe; figuring out distances and speeds; or figuring out prices and discounts. Moreover, in the lesson planning and presentation sessions, the usefulness of multiplication in quantitative data analysis; scaling and proportionality finance and in measurement, and area calculations was discussed. Therefore, TAs could make a convincing

argument for the usefulness of multiplication in real life when introducing the lessons.

This concludes the knowledge that was necessary to create the PCBS to teach, multiplication, for number sense.

Different aspects in the data from the planning and preparation stages that include brainstorming and lesson planning sessions, were combined and from these, three categories were identified forming part of theme two.

Theme 2: Collaborative Innovation in Teaching and Learning

To answer the second question of how the use of a participatory community-based strategy by a SEDC team can improve Grade 4 multiplication facts for learners, a discussion of the process followed by the team to create the PCBS will follow. Data will be used from the planning sessions, as well as some photographs to indicate the outcome of the groups' decisions. The three categories of the second question will be discussed in order, as they appear in Table 4 above.

- Brainstorming improves collaboration.

Before the above processes, i.e., lesson planning and presentation took place, the SEDC team attended a brainstorming session to generate ideas on how to help the Gr. 4 learners with their multiplication. This can be observed below Figure 5, depicting a photograph of the whiteboard that was used to capture ideas.

Brainstorming is an essential component of teamwork that can boost creativity, productivity, and the growth of closer bonds between members. The process of individuals or groups cooperating to accomplish a shared aim or target, is referred to as collaboration and entails pooling resources, ideas, and labour to complete projects, find solutions to issues, or produce something entirely new. Mutual engagement, communication, and cooperation among participants, each offering their distinct set of abilities, insights, and knowledge, are characteristics of collaboration (Owens & Wang, 1996).

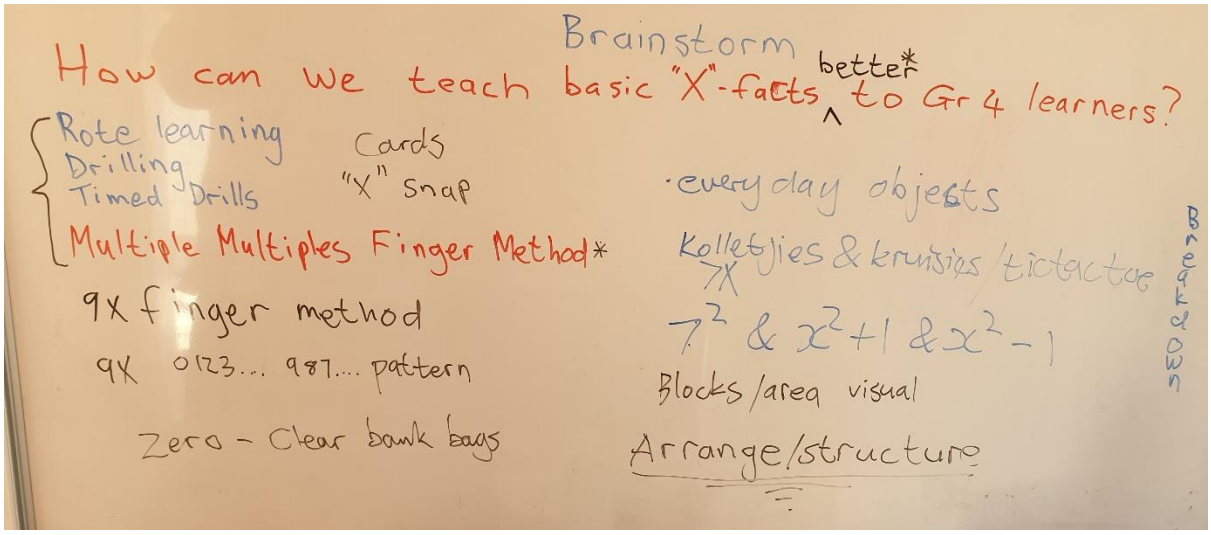

Figure 6: Brainstorming session to generate ideas for Gr. 4 intervention

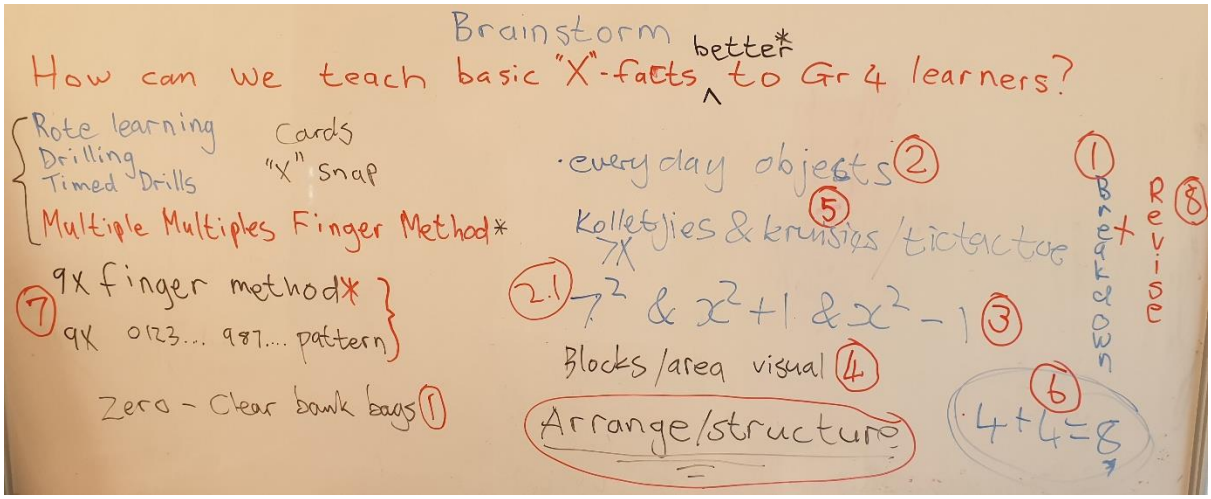

Figure 7: Brainstorming part 2, sequencing the intervention

It should be noted that from Figure 6 above, better was added to the question of "How can we teach basic 'multiplication-facts' to Gr. 4 learners?" Better was included, as after the first three suggestions of rote learning, drilling and timed drills was mentioned. After it was explained that we are collectively devising a way to teach better than previous generations were taught, better ideas surfaced.

Using cards and the "Snap" game was not used in the intervention, but this led the group to using games and the Tic-Tac-Toe idea was born. After the game was explained to the group by the contributing member, it was decided to use it. Making multiplication more fun and tactile, led to the use of the hands to show the nine times table. The hands method was discussed and that led to another nine times method that used the pattern formed by the multiples of nine.

By this point, members started to use their phones to look for better ways we could use. The aim was to find a new way that would work better, and could be used to teach the Gr. 4 learners. A method for eights' multiples was discovered and discussed, building on the sevens method and patterns formed by multiples. All of the numbered strategies in Figure 6 above were used in the intervention.

Although there are more categories under student diversity, the SEDC group identified learning styles and cognitive diversity. Different learning styles and strengths may be possessed by students, including auditory, kinaesthetic, visual, and other types of learning. Cognitive diversity refers to variations in cognitive capacities, such as varying IQs, methods for solving problems, and capacities for creativity (Landsberg, 2019, p. 127).

The use of the patterns, as well as the fingers methods for the multiples of nine attests to this realisation. Furthermore, involving the class in the various representations intervention deliberately caters for more diverse group learning to take place. Moreover, the area representation also caters for visual learners. Lastly, several lesson objectives in Table 4 have the specific aim of helping reduce the number of learners scoring zero for the Post-Test. Besides the intervention itself, the first and last lessons, overview, and revision of strategies, speak to this aim.

- Lesson presentations

Owing to COVID-19, the observations of the presentation of the lessons in class were not possible. We therefore had a lesson presentation meeting where the lessons in Table 3 were presented in the format shown in Figure 7. What we planned and presented, for the most part, unfolded in class the same way we had planned it. From this meeting, a complete strategy was written up, i.e., a complete set of lessons with the resources needed, introduction, body, and conclusion. TAs had the chance to each introduce a lesson and the SEDC team could make suggestions to add to the lesson. The body or doing the lesson was completed by the team for most worksheets. The conclusions were also covered in this manner.

Topic 3: Squares plus one multiple more or one multiple less intervention

Resources:

Double-sided Worksheet, squares representations from previous intervention

Introduction:

Explain that today we will learn more about numbers that multiply with themselves and use them to calculate sums near them.

Body:

Assist the class in filling out the meaning of the squares from 1 – 9, e.g., 2^2 = 2 x 2 = 4. Then use the information to calculate 2 x 3, using the squares plus one multiple more method, i.e., 2×3= ___×___+___=___ where 2×3= 2 × 2 + 2= 4 + 2 = 6. Complete the worksheet. If time allows, continue with squares minus one multiple or keep them for the next lesson.

The worksheet would then be turned over to complete the squares meaning again. Then used the information to calculate 4 x 3, using the squares minus one multiple less method, i.e., 4×3= ___×___-___=___ where 4×3= 4 × 4 – 4 = 16 - 4 = 12. The class completed this method for all problems on the worksheet.

Conclusion:

Verbally probe learners to explain the method they will use to calculate one multiple more than a squared number. Furthermore, check if learners comprehended when they could use this method. This method can be used where factors multiplied differ by one, i.e., 5 x 6 or 7 x 8.

Figure 8: Section 3 of the intervention Strategy from lesson presentation session

Figure 8 above, is another outflow of the brainstorming and planning stages. In Figure 8, the wonderful simplicity of the introduction should be observed. This introduction instruction was the result of a TA who explained the lesson introduction in these terms, which Gr. 4 learners would understand. Not only did this help the learners understand what the lesson was about; it also provided the rest of the SEDC team with a good way to introduce the lesson.

Feedback on the intervention came after the Post-Tests had been marked in the way of feedback on the Post-Test, compared to the Pre-Test, as well as general feedback on the entire intervention. The feedback stated

how the various forms of collaboration improved Gr. 4 multiplication. See below for some of the feedback.

The reflective feedback on the intervention that was diminished, due to late stipend payments from the project sponsors' payment system, creating similar dissatisfaction when NSFAS fails to pay university students on time. The short feedback that seven of the nine TAs provided, under non-ideal circumstances after the intervention, still stated how the various forms of collaboration improved Gr. 4 multiplication. Below, some of the verbatim feedback can be found:

I would not have thought of all these ways to teach multiplication by myself and I found that it works. I wish we had strategies like this when I was at school. It is good to work together to share ideas to help the kids. I do not see teachers doing this at schools.

This intervention has taught me a lot about planning lessons, and it has made my studies easier, since we started with this during the intervention for studies too. I am satisfied that my learners now know more about multiplication. The ideas generation was good, so we all helped to plan it.

I learnt so much about how to teach multiplication that is not as boring as it was for me. My future learners will have a good mathematics teacher because I have lots of practice now. The various strategies were good, as it helped kids to understand sums the way that they like to learn, I mean that you could choose what you like and what worked for you. We never had that.

I am grateful to SEDC who helped me to help the learners. My learners did much better using our strategies that we came up with. It was challenging at first but got better with the classes and then it was even better and now I feel it is best.

The work we did really helped me in my studies. Learnt new ways to teach. My classes showed a good improvement. The teacher was also happy with the results and the way we did it. There is still more to learn, the learners got a good idea now.

Before this I was still uncertain if I want to be a teacher, but having the opportunity to teach myself was hard but now I like it. I saw that with planning and working together you can make a change in the mathematics. Almost the whole learners got more sums correct in the

same time. It was good when I marked to see them use some of the things I taught them.

I realised that there are many different children and many different ways to make them understand. By working together we could help more children understand. Most children did understand more and they used different ways to do more of the sums.

From the feedback, it appears that the collaboration efforts were appreciated, since the intervention was better by incorporating many ideas, than simply one individual effort. Moreover, how to teach and teach better were mentioned in conjunction with learning in a supportive group. Furthermore, an improvement in the learners' performance was mentioned because of the strategies and teaching methods of the intervention. Positivity towards teaching and future teaching was expressed. There was mention of studies that improved after the use of the PCBS, indicating that students improved theoretically, after the practical experience of the intervention. There was mention of differentiated instruction to cater for different learner needs, after the intervention created that realisation.

This concludes how the PCBS came to be through collaborative participation in the above processes. Hereafter, other pertinent information that did not fit into the categories above, will be described in the general code.

Data from Reflection were the combination of Feedback on the intervention, after the Post-Test, and general feedback on the term's work; the data were categorised into two categories and presented under theme three.

Theme 3: Classroom organisation and discipline

The reflective general feedback instrument yielded data on the term's work, which mostly comprised the Gr. 4 intervention. The data originated after the intervention had taken place and had a reflective element. From the general feedback instrument, frequently mentioned experiences related to collaboration were derived at, through the process described in Figure 3 at the beginning of this section. However, more information not related to the research questions, but useful to the execution of the intervention emerged. The categories that emerged were classroom discipline and challenging school schedules, which will be discussed below.

- Classroom discipline

Classroom discipline describes the tactics and procedures teachers use to establish and uphold a supportive and organised learning environment. It entails setting and upholding guidelines and standards to encourage decency, teamwork, and a positive learning environment. Establishing an environment where students feel comfortable, interested, and able to concentrate on their academics, requires effective classroom discipline (Landsberg, 2019, p. 99).

From the general feedback instrument from all TA's, coupled with the realisation that classroom discipline is necessary for classroom management to work, statements followed that they had acquired this skill. "I realised that if children are kept constructively busy, they will always give you their cooperation". The PCBS can therefore also be thought of as a classroom management tool with planned, engaging activities, resources, and engagement tactics. However, communication was needed to establish and maintain class rules. "I managed to create an atmosphere of mutual respect in my classroom". Being present and engaging with the learners and establishing ground rules before the interaction, helped with the intervention. Once everyone in the class can feel safe under the rules laid out, fostering an environment where teaching and learning can occur is important.

Since the initial plans for the intervention changed due to COVID-19 and managing a class of 20-odd learners on one's own is more difficult than maintaining the focus of six learners in a small group-mediated session; thus, managing classroom discipline emerged as crucial. Keeping learners constructively busy, establishing mutual respect, and making use of the PCBS as discussed above, also aids in maintaining classroom discipline. The execution of the intervention was more complex than teaching a lesson plan.

Being a "role model" and establishing "relationship (with learners)" were outside the planned scope of the PCBS. Nevertheless, they were crucial in creating classroom discipline and ultimately valuable for the execution of the PCBS. Collaboration therefore was not only useful between the SEDC members, but also between the TA's (acting as teachers) and the Gr. 4 learners. Moreover, collaboration between TA's and schoolteachers also proved to be important, as will be described below.

- Challenging school schedules

Changes that had to be made outside the plans laid out in the PCBS by the team also featured frequently in the general feedback instrument. Having resources, being prepared, understanding the learners, and having a plan on how to move forward, were not always enough and these plans had sometimes to change. Owing to school events or unforeseen circumstances, such as water outages, planned lessons for some classes had to be rescheduled. Again, collaboration and relationships, now outside the SEDC group and the classroom, had to be employed to remedy the situation. Expanding the C in PCBS, to not only include learners, but also other schoolteachers, sometimes involved teaching different subjects. Negotiation for time in such events was necessary and fortunately given. Being prepared for possible unforeseen changes and moving forward despite the changes, emerged as useful in teaching and learning. Teaching is more complex than being a prepared teacher in a class; things can change, affecting the whole school. Therefore, to rectify unplanned changes, teachers of other classes can aid in this endeavour.

4.3 THE MERGING OF THEMES

From the quantitative data, there were two instruments, the Pre- and Post-Tests, from which a hypothesis was selected, and feedback after the Pre- and Post-Test that were analysed by content analysis. Both the instruments for the quantitative analysis indicated an improvement in areas where Gr. 4 learners were previously lacking in the knowledge of multiplication facts learning.

From the qualitative data there were three themes that emerged from the data of the instruments used. Data from the brainstorming and planning, lesson presentation and feedback were merged to reduce the number of themes from each instrument used for the qualitative analysis.

Themes that emerged from the quantitative and qualitative analysis were merged and the process is briefly described below:

The research questions were taken as a priori themes for the quantitative analysis and the two instruments yielded the following results.

Quantitative data was analysed to see whether the following hypothesis would hold up. First, the null hypothesis states that there will be no increase in marks from Pre-Test to Post-Test after the PCBS was used to administer a multiplication intervention. Second, the alternative hypothesis states that there will be an increase in marks from the Pre-Test to the Post-Test after the PCBS was used to administer a multiplication intervention, which was accepted. Therefore, the null hypothesis was

rejected and hence forth the focus would be how an improvement was made and not, if an improvement was made. This is then priory Theme 1. Moreover, multiplication, including the larger multiplicands and multiplication by zero, as well as methods and strategies used by learners to gauge whether they would improve or not. The analysis was found to be in the affirmative of the former, and this is then priory Theme 2.

Themes that emerged from the qualitative analysis derived from the 3 grouped instruments were:

Theme 1: Knowledge needed by the SEDC team;

Theme 2: Collaborative innovation in teaching and learning; and

Theme 3: Classroom organisation and discipline;

The emergent themes from the quantitative and qualitative instruments were merged to reduce the number of themes. The combined themes will be presented as findings below. Theme 1 from the qualitative analysis is specific to the research questions and can be merged with emergent priori theme 1 from quantitative data, to create the theme of: The knowledge needed by the SEDC team to teach multiplication for improved number sense of Gr. 4 learners. Priori theme 2 merged with emergent theme 2 and was phrased as: Collaborative Innovation in Teaching and Learning for the Improvement of Gr. 4 learners' multiplication fact learning. Theme 3 emerged from the feedback instrument and is relevant to the study, but unrelated to the research questions. Therefore, Theme 3 emerged as a general theme. The combined themes will be presented as findings below.

Specific Themes that are related to study objectives

- The knowledge needed by the SEDC team to teach multiplication for improved number sense of Gr. 4 learners.
- Collaborative innovation in teaching and learning for the improvement of Gr. 4 learners' multiplication fact learning.

General Theme

- Classroom organisation and discipline

4.4 CONCLUSION

In this chapter the data analysis process was discussed. Various outcomes from the data were discussed. Discussions led to codes, categories and themes that emerged. Emergent themes from the

quantitative and qualitative data were merged. The themes led to specific themes relevant to the study objectives and general themes that were relevant and not related to the study objectives.

The specific and general themes will be discussed in the next chapter as the findings of the study. Implications and recommendations will then follow.

CHAPTER 5: DISCUSSION OF FINDINGS, IMPLICATIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter covers both the particular findings that are pertinent to the study's goals and the broader conclusions that can be drawn from the data but have no bearing on the goals themselves. There is a discussion of the general and specific implications of the findings. Recommendations are given for additional research and the limitations are discussed.

5.2 FINDINGS

The discussion of the findings is divided into the findings specific to the research objectives and later, general findings. General findings are not related to the study's objective but are pertinent, and emerged from the data. Below find a reminder of the study's main aim and secondary objectives.

The aim of this study was to investigate whether a participatory community-based strategy can improve the number sense of Grade 4 learners, particularly concerning multiplication facts.

The objectives of the research were:

- to identify the knowledge needed by SEDC teachers and assistants to teach Grade 4 multiplication facts, using a participatory community-based strategy; and

- to establish how SEDC teachers and assistants use a participatory community-based strategy to teach Grade 4 multiplication facts to learners.

Findings for discussion:

Specific Findings that are related to study objectives

- The knowledge needed by the SEDC team to teach multiplication for improved number sense of Gr. 4 learners.
- Collaborative innovation in teaching and learning for the improvement of Gr. 4 learners' multiplication fact learning.

General Finding

- Classroom organisation and discipline

5.2.1 Specific Finding 1: The knowledge needed by the SEDC team to teach multiplication for improved number sense of Gr. 4 learners

Quantitative analysis indicated that the intervention yielded a statistically significant improvement. Learners across the spectrum of abilities performed better. This means the SEDC team had knowledge of their learners and knew how to interact with them in a meaningful way, and were able to function well in the schools to effect positive change. Taking information from Table 2 and Figure 3 into account, the null hypothesis is rejected, and the alternative hypothesis is accepted. There was an increase in marks from Pre-Test to Post-Test after the PCBS was used to administer a multiplication intervention. Overall, an average increase of 20,06% was achieved across all the sampled Gr. 4 learners. Feedback from the SEDC team indicated that they observed improvements from Pre-Test to Post-Test, especially in the identified problem areas that the intervention aimed to improve. Furthermore, from the qualitative data, the SEDC team gathered knowledge of the Gr. 4 learners' multiplication skills and identified areas for improvement. This cascaded the knowledge needed for improvement in the identified areas. Strategies were discussed to improve multiplication by zero, six, seven, eight and nine. Therefore, mathematics content knowledge and knowledge of the curriculum, was used. Moreover, the distributive property of multiplication was deemed useful, as not to recalculate the same sums, e.g. 6 x 4 and 4 x 6.

Data from the quantitative analysis indicated that working together was useful to plan and execute lessons that would make multiplication knowledge relevant to the Gr. 4 learners. The use of number talks, tangible and real-world examples, fact families and visual representations, were useful to achieve an improvement in Gr. 4 learners' marks from Pre-Test to Post-Test.

5.2.2 Specific Finding 2: Collaborative Innovation in Teaching and Learning for the Improvement of Gr. 4 learners' multiplication fact learning

The PCBS devised by the SEDC team seemed to benefit learners, irrespective of their level of multiplication knowledge. From Table 1 it is

evident that learners with higher and lower multiplication knowledge, both benefited from the intervention, as both schools with a higher and lower Pre-Test average, showed a significant improvement in marks after the Post-Test. Moreover, from Table 2, the high standard deviation could indicate a wide variety of cognitive developmental stages or abilities. However, the increase in test scores indicate that all learners of all cognitive developmental stages, had some increase in marks.

In Table 2 the very small p-value was also an indication that the increase was likely due to the interventions that the Gr. 4 learners received. However, due to purpose of the study – improving Gr. 4 multiplication in a way conducive to number sense development – and the means the study wished to bring about this change – through a Participatory Community-Based Strategy – no one involved in the study would claim the results were exclusively due to their sole intervention. Thus, through participation of and collaboration with the wider community, a positive result was more likely. The mean score in Table 2 of 9,62 marks or 29,14%, suggests that multiplication knowledge was poor at the time of the Pre-Test. Likewise, the mean score of 16,24 marks or 49,20% suggests that, although not stellar, the multiplication knowledge of the Gr. 4 cohort is 20,06% higher than it was before the intervention. The PCBS seems effective in increasing basic multiplication facts and knowledge. Therefore, by working together (using the PCBS correctly) everyone helps everyone grow.

The qualitative data indicated that working together greatly improved the intervention by listening and using a group's ideas. The SEDC team agreed that a collective effort was better than any individual effort would have been. From the brainstorming and later the lesson planning and presentation meetings, the group helped each other prepare for the intervention.

5.2.3 General Finding: Classroom organisation and discipline

Classroom organisation goes beyond the classroom; this was a realisation that the bigger school programme has implications for the work that has to be covered in the classroom.

From the general feedback by the SEDC team, it became apparent that there can be no teaching and learning before there is proper classroom discipline. Strategies mentioned to establish classroom discipline were setting class rules with the learners and establishing mutual respect.

5.3 Implications

5.3.1 IMPLICATION FOR FINDING 1

The quantitative data showed an overall improvement in test scores across the spectrum of the Gr. 4 learners. A consistent improvement per school and over the entire group was observed. Therefore, there was a statistically significant improvement caused by using a PCBS to improve Gr. 4 learners' multiplication marks. From the planning and the execution of the plan, observations and reflections were made on the performance of the learners, after writing the multiplication test and obtaining an average increase of over 20%.

Qualitative data from the Pre- and Post-Test feedback indicates that there was an overall improvement in the multiplication problems answered correctly, including 0, 6, 7, 8 and 9 multiplication problems. Moreover, improved strategies and methods were reported. Another factor that was mentioned was a reduction in stress. Thus, deciding to focus on the associative property of multiplication, enhancing learners' estimation skills and demonstrating patterns formed by multiples (i.e., the element in Table 3 that the intervention covered), had some success in improving learners' marks. The quantitative data tell us that there was a twenty percent improvement.

Qualitative data from the planning session on the intervention, indicates that knowledge of conceptual comprehension and mathematical connections, instructional techniques, and participation, as well as knowledge of the application and connection to real-life situations of multiplication was needed to successfully teach Gr. 4 learners basic multiplication facts in a manner conducive to number sense development. The positive outcomes of number sense from the work of Ben-Yuhuda & Sharoni (2021) and May (2020) agrees mostly with the outcomes observed in this study.

5.3.2 IMPLICATION FOR FINDING 2

Qualitative data from the planning session on the intervention indicate that collaboration could be a better way to improve student learning. Planning lessons together aids in the creation and execution of an intervention strategy. Qualitative data from the planning session on the intervention, indicate that the recognition of student diversity is essential for creating a strategy that can cater for the specific needs of the learners. The researcher agrees with the notions of Zuber-Skerrit, et al., (2020) that

community based learning and the PALAR process is a good combination to achieve the above mentioned findings.

The TA's showed dedication and perseverance throughout the whole intervention programme. This leads the researcher to conclude that involving people in the decisions surrounding their work can help motivate people to show more dedication to their work. TA's were part of the planning of the intervention and were instrumental in the execution of the plan. A shared goal also included a group that could support one another and discuss strategies together.

The general feedback led the researcher to conclude that community based learning provides relevant work experience and prepares youth for the future by providing real-world, meaningful, work experience. The researcher agrees with Cassim & Moen (2020) that TA's are helping and are helped by working in the schools. The TA's were more motivated to participate in the intervention programme as it was structured to help them, whilst they helped the school. Participation in the intervention helped TA's with their studies and prepared them for future employment. The school benefits from having teachers who are assisted and learners who are exposed to beneficial teaching strategies.

The use of participatory practices to prepare and place externally funded permanent TA's in local schools to support mathematics learning is another way to stem the poor mathematics performance of learners. Placing TA's in schools under the supervision of SEDC teachers and HOD's, increases the amount of support, mentorship and experience TA's may gain.

5.3.3 IMPLICATION FOR FINDING 3

Qualitative data from the general feedback on the intervention indicate that classroom discipline is necessary to execute a strategy (Landsberg, 2019, p. 99). Moreover, adaptability to unforeseen changes is part of being able to successfully execute an intervention strategy. Anyone teaching or attempting to teach, should keep in mind that there will not be proper teaching and learning without discipline. Having a plan for instilling and maintaining classroom discipline is essential in the context that the research study took place.

5.4 Conclusions

The study assumed that the improvement in marks indicates that several other factors had to improve. These factors included an improvement of the learners' knowledge of the distributive property of multiplication. From the Pre-Tests and Post-Tests it can be seen that similar sums, e.g., 6x4 and 4x6 were answered correctly in the Post-Test, compared to the Pre-Test. The Pre-Test and Post-Test were the same. However, where for example, 2x3 was asked in the Pre-Test, 3x2 was asked in the Post-Test. Furthermore, it is assumed number sense improves if mental calculation speed, estimation, accuracy and strategies improve. Moreover, the researcher assumed the feedback from the TA's was a reflection of their true feelings and how they experienced the intervention.

The research questions aimed to answer if a PCBS could improve the number sense of Gr. 4 learners pertaining to multiplication. Evidence gathered suggested a PCBS could improve Gr. 4 learners' number sense with regard to multiplication. The knowledge needed for the afore-mentioned improvement was investigated, together with how the PCBS was devised, was also discussed.

The study eventually used mixed methods to answer the research questions. The advent of COVID-19 and how the data were analysed, changed from the original plan; however, measures were taken to ensure the validity and reliability of the findings.

The findings discussed the knowledge needed by the SEDC team, as well as how the SEDC team collaborated to create interventions that could meaningfully help Gr. 4 learners to improve their multiplication and number sense.

There was no literature the researcher could find concerning the use of a community project in school time, to assist teachers to improve mathematics. Therefore, this study adds to the body of knowledge.

Recommendations

Using TA's are good and their use in South Africa will likely increase just as in Australia, who have a similar curriculum to CAPS (Cassim & Moen, 2020). The researcher would suggest that, where possible, the permanent and gainful employment of TA's should be investigated for the enhancement of STEM goals, instead of sporadic short-term, untrained and not mentored employment.

The amalgamation of qualitative observations and quantitative findings underscores the effectiveness of a cooperative and interactive methodology in augmenting the educational encounter and achievements of pupils. According to the study's findings, these tactics not only create a positive learning atmosphere but also enhance long-term academic gains. As such, they serve as a model for educational interventions in settings comparable to this one.

This study recommends that further studies be carried out pertaining to the efforts of outside stakeholders attempting an improvement in mathematics in the intermediate phase.

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APPENDICES

APPENDIX A: APPROVAL OF ETHICAL CLEARANCE

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA

UFS UV

GENERAL/HUMAN RESEARCH ETHICS COMMITTEE (GHREC)

16-Mar-2021

Dear Mr Gerrit Cloete

Application Approved

Research Project Title:
A participatory community-based strategy to improve Grade 4 learners' number sense in multiplication.

Ethical Clearance number:
UFS-HSD2020/2114/163

We are pleased to inform you that your application for ethical clearance has been approved. Your ethical clearance is valid for twelve (12) months from the date of issue. We request that any changes that may take place during the course of your study/research project be submitted to the ethics office to ensure ethical transparency. furthermore, you are requested to submit the final report of your study/research project to the ethics office. Should you require more time to complete this research, please apply for an extension. Thank you for submitting your proposal for ethical clearance; we wish you the best of luck and success with your research.

Yours sincerely

Dr Adri Du Plessis
Chairperson: General/Human Research Ethics Committee

Adri du Plessis
Digitally signed by Adri du Plessis
Date: 2021.03.16 15:00:53 +02'00'

205 Nelson Mandela Drive
Park West
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South Africa

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Bloemfontein 9300
Tel: +27 (0)51 401 9337
duplessisA@ufs.ac.za
www.ufs.ac.za

APPENDIX B: APPLICATION LETTER TO CONDUCT RESEARCH: DEPARTMENT OF EDUCATION

Gerrit Johannes Cloete

60 Leo Cresent

De Aar

7000

REQUEST FOR PERMISSION TO CONDUCT RESEARCH

Dear *Mr. Olifant* Chief Educational Specialist

I am undertaking research for the University of the Freestate and would like to request permission to do my research at four schools in De Aar in the Pixley ka Seme District, Northern Cape: Willie Theron Primary school, Emthanjeni Primary school, St. John's Primary school, Alpha Primary school and Kareeville Primary school.

DATE

November 2020

TITLE OF THE RESEARCH PROJECT

A participatory community-based strategy to improve Grade 4 learners' number sense in multiplication.

PRINCIPLE INVESTIGATOR / RESEARCHER(S) NAME(S) AND CONTACT NUMBER(S):

Gerrit Cloete 2016255834 *Cell: 063 854 3230*

FACULTY AND DEPARTMENT:

School of Mathematics, Natural Sciences and Technology Education

STUDYLEADER NAME AND CONTACT NUMBER:

Dr Msebenzi Rabaza

051 401 2307

WHAT IS THE AIM / PURPOSE OF THE STUDY?

The aim of this study is to investigate whether a participatory community-based strategy can improve the number sense of Grade 4 learners, particularly concerning multiplication facts. The bigger purpose of this study is to find effective ways to teach for number sense benefitting the learners, their teachers and the pre-service teachers participating in the research project.

WHO IS DOING THE RESEARCH?

I will be the primary researcher, however as the study will make use of participatory action research the whole team, consisting of two teachers and 10 assistant teachers/students, of the Socio

Economic Development Company (SEDC) will be positioned as co-researchers to draw from as wide a perspective as possible about the project.

HAS THE STUDY RECEIVED ETHICAL APPROVAL?

This study has received approval from the Research Ethics Committee of UFS. A copy of the approval letter can be obtained from the researcher.

Approval number: **UFS-HSD2020/2114/163**

WHY ARE YOUR INSTITUTION/ORGANISATION/COMPANY INVITED TO TAKE PART IN THIS RESEARCH PROJECT?

The researcher, as a team member of the SEDC projects firstly in Douglas and then in De Aar, has observed that learners in the primary grades perform poorly in number sense. In the establishment of the SEDC project in 2014, its primary focus was the high failure and dropout rate of Grade 9 learners. Later, the project aim was to start, from Grade 1, to enhance conceptual rather than procedural understanding in mathematics, based on observation and unsolicited responses from teachers and principals that the number sense (and results) of learners had been improved by the SEDC project. Therefore, the study will investigate whether the participatory community-based strategy improves the number sense of Grade 4 learners.

WHAT IS THE NATURE OF PARTICIPATION IN THIS STUDY?

Learners of the above mentioned schools will participate in this study for one school term for half an hour per week, during this time they will write a pre- and post-test and receive 6 small group mediated sessions with the research participants of the SEDC project. A pre-test aligned with the Curriculum and Assessment Policy Statement will be written by Grade 4 learners, marked by the SEDC team and the data captured. This will catalyse participatory action research cycles to improve Grade 4 mathematics. The cycle will start with the SEDC members as co-researchers contributing their personal observations of the errors made by the learners, followed by a brainstorming session on strategies to correct these errors. Thereafter, a focus group discussion will be conducted to develop an action plan to reach the first participatory action research objective of improving the teaching of Grade 4 basic multiplication facts. This plan will be implemented and executed, after which a post-test, marking, data capturing, personal observations and data gathered will be used and discussed in a focus group format to evaluate the success of the intervention. The focus groups will be recorded and small group sessions will be accompanied by personal observation by the SEDC teachers during mediation sessions. All planning and preparation and meetings will be during normal working hours for the SEDC students.

WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THIS STUDY?

The learners will benefit from the mediated small group interaction with a ratio of one to six and their multiplication facts and number sense might improve. School mathematics teachers might benefit from their learners having increased number sense and knowing their multiplication facts better. The SEDC participants who are mostly education students will benefit from practical experience in the teaching and learning of mathematics.

WHAT IS THE POTENTIAL RISKS TAKING PART IN THIS STUDY?

The is little or no risk for learners as all information is treated as confidential and anonymity is assured by using codes or pseudonyms for all participants. Mathematics teachers might feel they are losing some teaching time, however this has already been negotiated with schools that form part of the project and the time the research will take up takes less time than the allotted amount of time prescribed for mental calculations, which this study aims to improve. SEDC students might feel uncomfortable being observed during their small group interactions, however they will be informed what is being observed and receive proper training before each session. During focus group discussions SEDC students will be reminded not to share information of a sensitive or personal nature as the researcher cannot guarantee that other participants will keep their shared information confidential.

WILL THE INFORMATION BE KEPT CONFIDENTIAL?

Yes, all data gathered will be processed and only codes or pseudonyms will be used so no participant will be individually identifiable. Only the researcher and his supervisor will have access to the data, processed data might be used in articles and conferences, but no participant will be identifiable from these practices. Where other participants might break confidentiality the participants will be reminded not to share sensitive or personal information. All participants will be informed and agree to how data will be disseminated.

HOW WILL THE INFORMATION BE STORED AND ULTIMATELY DESTROYED?

Data will be kept on a password protected computer, hard copies will be locked in a cupboard and destroyed after 3 years. Recordings of focus groups will be deleted after the study is completed.

WILL THERE BE PAYMENT OR ANY INCENTIVES FOR PARTICIPATING IN THIS STUDY?

There will not be payment or other incentives for participating in this study besides the possible benefits mentioned above.

HOW WILL THE INSTITUTION / ORGANISATION / COMPANY BE INFORMED OF THE FINDINGS / RESULTS OF THE STUDY?

Please contact me, Gerrit Cloete, on 063 854 3230 or gerriecloete@gmail.com, if you would like to be informed about the final research findings. If there are any concerns about the manner in which any part of the research has been conducted, please contact Dr Rabaza on 051 401 2307. Please bear in mind that all information given to you should be treated with confidentiality.

Yours sincerely

Gerrit Cloete

APPENDIX C: APPLICATION LETTER TO SCHOOLS TO CONDUCT RESEARCH

REQUEST FOR PERMISSION TO CONDUCT RESEARCH

Dear *Sir/Madam*

I am undertaking research and would like to request permission to do my research at your school in De Aar in the Pixley ka Seme District, Northern Cape: Willie Theron Primary school, St. John's Primary school, Alpha Primary school and Kareeville Primary school.

DATE

November 2020

TITLE OF THE RESEARCH PROJECT

A participatory community-based strategy to improve Grade 4 learners' number sense in multiplication.

PRINCIPLE INVESTIGATOR / RESEARCHER(S) NAME(S) AND CONTACT NUMBER(S):

Gerrit Cloete 2016255834 *Cell: 063 854 3230*

FACULTY AND DEPARTMENT:

School of Mathematics, Natural Sciences and Technology Education

STUDYLEADER NAME AND CONTACT NUMBER:

Dr Msebenzi Rabaza

051 401 2307

WHAT IS THE AIM / PURPOSE OF THE STUDY?

The aim of this study is to investigate whether a participatory community-based strategy can improve the number sense of Grade 4 learners, particularly concerning multiplication facts. The bigger purpose of this study is to find effective ways to teach for number sense benefitting the learners, their teachers and the pre-service teachers participating in the research project.

WHO IS DOING THE RESEARCH?

I will be the primary researcher, however as the study will make use of participatory action research the whole team, consisting of two teachers and 10 assistant teachers/students, of the Socio Economic Development Company (SEDC) will be positioned as co-researchers to draw from as wide a perspective as possible about the project.

HAS THE STUDY RECEIVED ETHICAL APPROVAL?

Approval number: *UFS-HSD2020/2114/0*

WHY ARE YOUR INSTITUTION/ORGANISATION/COMPANY INVITED TO TAKE PART IN THIS RESEARCH PROJECT?

The researcher, as a team member of the SEDC projects firstly in Douglas and then in De Aar, has observed that learners in the primary grades perform poorly in number sense. In the establishment of the SEDC project in 2014, its primary focus was the high failure and dropout rate of Grade 9 learners. Later, the project aim was to start, from Grade 1, to enhance conceptual rather than procedural understanding in mathematics, based on observation and unsolicited responses from teachers and principals that the number sense (and results) of learners had been improved by the SEDC project. Therefore, the study will investigate whether the participatory community-based strategy improves the number sense of Grade 4 learners.

WHAT IS THE NATURE OF PARTICIPATION IN THIS STUDY?

Learners of the above mentioned schools will participate in this study for one school term for half an hour per week, during this time they will write a pre- and post-test and receive 6 small group mediated sessions with the research participants of the SEDC project. A pre-test aligned with the Curriculum and Assessment Policy Statement will be written by Grade 4 learners, marked by the SEDC team and the data captured. This will catalyse participatory action research cycles to improve Grade 4 mathematics. The cycle will start with the SEDC members as co-researchers contributing their personal observations of the errors made by the learners, followed by a brainstorming session on strategies to correct these errors. Thereafter, a focus group discussion will be conducted to develop an action plan to reach the first participatory action research objective of improving the teaching of Grade 4 basic multiplication facts. This plan will be implemented and executed, after which a post-test, marking, data capturing, personal observations and data gathered will be used and discussed in a focus group format to evaluate the success of the intervention. The focus groups will be recorded and small group sessions will be accompanied by personal observation by the SEDC teachers during mediation sessions. All planning and preparation and meetings will be during normal working hours for the SEDC students.

WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THIS STUDY?

The learners will benefit from the mediated small group interaction with a ratio of one to six and their multiplication facts and number sense might improve. School mathematics teachers might benefit from their learners having increased number sense and knowing their multiplication facts better. The SEDC participants who are mostly education students will benefit from practical experience in the teaching and learning of mathematics.

WHAT IS THE POTENTIAL RISKS TAKING PART IN THIS STUDY?

The is little or no risk for learners as all information is treated as confidential and anonymity is assured by using codes or pseudonyms for all participants. Mathematics teachers might feel they are losing some teaching time, however this has already been negotiated with schools that form part of the project and the time the research will take up takes less time than the allotted amount of time prescribed for mental calculations, which this study aims to improve. SEDC students might feel uncomfortable being observed during their small group interactions, however they will be informed what is being observed and receive proper training before each session. During focus group discussions SEDC students will be reminded not to share information of a sensitive or personal nature as the researcher cannot guarantee that other participants will keep their shared information confidential.

WILL THE INFORMATION BE KEPT CONFIDENTIAL?

Yes, all data gathered will be processed and only codes or pseudonyms will be used so no participant will be individually identifiable. Only the researcher and his supervisor will have access to the data, processed data might be used in articles and conferences, but no participant will be identifiable from these practices. Where other participants might break confidentiality the participants will be reminded not to share sensitive or personal information. All participants will be informed and agree to how data will be disseminated.

HOW WILL THE INFORMATION BE STORED AND ULTIMATELY DESTROYED?

Data will be kept on a password protected computer, hard copies will be locked in a cupboard and destroyed after 3 years. Recordings of focus groups will be deleted after the study is completed.

WILL THERE BE PAYMENT OR ANY INCENTIVES FOR PARTICIPATING IN THIS STUDY?

There will not be payment or other incentives for participating in this study besides the possible benefits mentioned above.

HOW WILL THE INSTITUTION / ORGANISATION / COMPANY BE INFORMED OF THE FINDINGS / RESULTS OF THE STUDY?

Please contact me, Gerrit Cloete, on 063 854 3230 or gerriecloete@gmail.com, if you would like to be informed about the final research findings. If there are any concerns about the manner in which any part of the research has been conducted, please contact Dr Rabaza on 051 401 2307. Please bear in mind that all information given to you should be treated with confidentiality.

Yours sincerely

Gerrit Cloete

APPENDIX D: APPROVAL TO CONDUCT RESEARCH: DEPARTMENT OF EDUCATION

Northern Cape
Department of Education
PIXLEY KA SEME DISTRICT
Alpha Road
Happy Vally
De Aar 7000
Private Bag X1013
De Aar 7000
Republic of South Africa
Tel: 053 632 9200
Fax: 053 631 3250

DEPARTMENT OF EDUCATION

Enquiries: F. Silengile
Contact No: 0769255919 / 0536329229
Date: 10 February 2021

TO: Gerrit Johannes Cloete

SUBJECT: APPROVAL FOR CONDUCTING RESEACH IN THE FIVE IDENTIFIED SCHOOLS OF PIXLEY KA SEME DISTRICT OF EDUCATION.

TITLE OF THE RESEARCH PROJECT:

A participatory community based strategy to improve Grade 4 learners' number sense in multiplication.

List of schools involved: Willie Theron PS, Emthanjeni PS, St John's PS, Alpha PS and Kareeville PS

Duration: January – December 2021

The Pixley Ka Seme district of Education in the Northern Cape Province welcomes your request to conduct a research in the five identified schools of Emthanjeni Circuit. Your approach is Participatory Action Research (PAR) which, by its nature is interactive, empowering and emphasizing on collective inquiry. The district wishes that your research will benefit the teachers and help to lay a solid foundation for the learners to master the basic concepts of mathematics in the lower grades.

When conducting your research, the following must be strictly adhered to:
(a) COVID-19 protocols
(b) All schools have to recover the learning losses caused by the pandemic, therefore learning and teaching time must be protected.
(c) Ethical consideration
(d) All the assessment results of the school are highly confidential, may be used for your research purpose only and not divulged to the third party.

Any violation of the above non-negotiables may lead to the approval being reviewed.

The Pixley Ka Seme district wishes you well in your endeavors to pursue your studies towards a Masters degree programme.

Yours Faithfully

F. Silengile
Acting District Director: Pixley ka Seme

Page 1 of 1

APPENDIX E: INFORMATION LEAFLET AND PARTICIPANT CONSENT FORM

RESEARCH STUDY INFORMATION LEAFLET AND CONSENT FORM

DATE
17 March 2021

TITLE OF THE RESEARCH PROJECT

A participatory community-based strategy to improve Grade 4 learners' number sense in multiplication.

PRINCIPLE INVESTIGATOR / RESEARCHER(S) NAME(S) AND CONTACT NUMBER(S):

Gerrit Cloete 2016255834 Cell: 063 854 3230

FACULTY AND DEPARTMENT:
Education
School of Mathematics, Natural Sciences and Technology Education
STUDYLEADER(S) NAME AND CONTACT NUMBER:

Dr Msebenzi Rabaza
051 401 2307

WHAT IS THE AIM / PURPOSE OF THE STUDY?

The aim of this study is to investigate whether a participatory community-based strategy can improve the number sense of Grade 4 learners, particularly concerning multiplication facts. The bigger purpose of this study is to find effective ways to teach for number sense benefitting the learners, their teachers and the pre-service teachers participating in the research project.

WHO IS DOING THE RESEARCH?

I will be the primary researcher, however as the study will make use of participatory action research the whole team, consisting of two teachers and 10 assistant teachers/students, of the Socio Economic Development Company (SEDC) will be positioned as co-researchers to draw from as wide a perspective as possible about the project.

HAS THE STUDY RECEIVED ETHICAL APPROVAL?

This study has received approval from the Research Ethics Committee of UFS. A copy of the approval letter can be obtained from the researcher.

Approval number: *UFS-HSD2020/2114/163*

WHY ARE YOU INVITED TO TAKE PART IN THIS RESEARCH PROJECT?

The target population of the research will be 612 Grade 4 learners in five primary schools in De Aar, Northern Cape, in the Pixley ka Seme education district, who form part of the SEDC programme.

Convenience sampling will be used to select the participants, as these low-quintile schools form part of the SEDC project and the researcher will have easy access to them. Convenience sampling will also be used to gather data from the 12 members of the SEDC.

WHAT IS THE NATURE OF PARTICIPATION IN THIS STUDY?

Learners of the above mentioned schools will participate in this study for one school term for half an hour per week, during this time they will write a pre- and post-test and receive 6 small group mediated sessions with the research participants of the SEDC project. A pre-test aligned with the Curriculum and Assessment Policy Statement will be written by Grade 4 learners, marked by the SEDC team and the data captured. This will catalyse participatory action research cycles to improve Grade 4 mathematics. The cycle will start with the SEDC members as co-researchers contributing their personal observations of the errors made by the learners, followed by a brainstorming session on strategies to correct these errors. Thereafter, a focus group discussion will be conducted to develop an action plan to reach the first participatory action research objective of improving the teaching of Grade 4 basic multiplication facts. This plan will be implemented and executed, after which a post-test, marking, data capturing, personal observations and data gathered will be used and discussed in a focus group format to evaluate the success of the intervention. The focus groups will be recorded and small group sessions will be accompanied by personal observation by the SEDC teachers during mediation sessions. All planning and preparation and meetings will be during normal working hours for the SEDC students.

CAN THE PARTICIPANT WITHDRAW FROM THE STUDY?

Participation is voluntary and there is no penalty or loss of benefit for non-participation. Being in this study is voluntary and you are under no obligation to consent to participation. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a written consent form. You are free to withdraw at any time and without giving a reason.

WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THIS STUDY?

The learners will benefit from the mediated small group interaction with a ratio of one to six and their multiplication facts and number sense might improve. School mathematics teachers might benefit from their learners having increased number sense and knowing their multiplication facts better. The SEDC participants who are mostly education students will benefit from practical experience in the teaching and learning of mathematics.

WHAT IS THE ANTICIPATED INCONVENIENCE OF TAKING PART IN THIS STUDY?

The is little or no risk for learners as all information is treated as confidential and anonymity is assured by using codes or pseudonyms for all participants. Mathematics teachers might feel they are losing some teaching time, however this has already been negotiated with schools that form part of the project and the time the research will take up takes less time than the allotted amount of time prescribed for mental calculations, which this study aims to improve. SEDC students might feel uncomfortable being observed during their small group interactions, however they will be informed what is being observed and receive proper training before each session. During focus group discussions SEDC students will be reminded not to share information of a sensitive or personal nature as the researcher cannot guarantee that other participants will keep their shared information confidential.

WILL WHAT I SAY BE KEPT CONFIDENTIAL?

Yes, all data gathered will be processed and only codes or pseudonyms will be used so no participant will be individually identifiable. Only the researcher and his supervisor will have access to the data, processed data might be used in articles and conferences, but no participant will be identifiable from these practices. Where other participants might break confidentiality the participants will be reminded

not to share sensitive or personal information. All participants will be informed and agree to how data will be disseminated.

HOW WILL THE INFORMATION BE STORED AND ULTIMATELY DESTROYED?

Hard copies of your answers will be stored by the researcher for a period of five years in a locked cupboard/filing cabinet in my office for future research or academic purposes; electronic information will be stored on a password protected computer. Future use of the stored data will be subject to further Research Ethics Review and approval if applicable. Recordings of focus groups will be deleted after the study is completed.

WILL I RECEIVE PAYMENT OR ANY INCENTIVES FOR PARTICPATING IN THIS STUDY?

There will not be payment or other incentives for participating in this study besides the possible benefits mentioned above.

HOW WILL THE PARTICIPANT BE INFORMED OF THE FINDINGS / RESULTS OF THE STUDY?

Please contact me, Gerrit Cloete, on 063 854 3230 or gerriecloete@gmail.com, if you would like to be informed about the final research findings. If there are any concerns about the manner in which any part of the research has been conducted, please contact Dr Rabaza on 051 401 2307. Please bear in mind that all information given to you should be treated with confidentiality.

Thank you for taking time to read this information sheet and for participating in this study.

APPENDIX F: PARENTAL/GUARDIAN CONSENT FORM

RESEARCH STUDY INFORMATION LEAFLET AND PARENTAL CONSENT FORM

DATE

November 2020

TITLE OF THE RESEARCH PROJECT

A participatory community-based strategy to improve Grade 4 learners' number sense in multiplication.

PRINCIPLE INVESTIGATOR / RESEARCHER(S) NAME(S) AND CONTACT NUMBER(S):

Gerrit Cloete 2016255834 *Cell: 063 854 3230*

FACULTY AND DEPARTMENT:

School of Mathematics, Natural Sciences and Technology Education.

STUDYLEADER NAME AND CONTACT NUMBER:

Dr Msebenzi Rabaza

051 401 2307

WHAT IS RESEARCH ABOUT?

The research will be about how well the SEDC group can teach Grade 4 children their multiplication facts.

WHO IS DOING THE RESEARCH?

I will be the primary researcher, however the study will make use of the whole team, consisting of two teachers and 10 assistant teachers/students, of the Socio Economic Development Company (SEDC).

HAS THE STUDY RECEIVED ETHICAL APPROVAL?

Approval number: *UFS-HSD2020/2114/0*

WHY HAS YOUR CHILD BEEN INVITED TO TAKE PART IN THIS PROJECT?

Grade 4 learners will write a test in the beginning of the project, this test will be looked at to see how best to help the learners. The SEDC team will then make a plan and teach the Grade 4 learners in small groups about multiplication. Then another test will be will be written to see how well the SEDC group taught the Grade 4 learners.

WHAT WILL HAPPEN TO MY CHILD IN THIS STUDY?

Besides the two tests in the beginning and end of the study, the SEDC team will work with groups of learner for a half hour each week for six weeks, helping Grade 4 learners to better understand and do multiplication using various methods to teach multiplication facts from 0 to 9.

CAN ANYTHING BAD HAPPEN TO YOUR CHILD?

Learners will not be harmed during this study as it aims to increase how well they do and understand their multiplication facts. There will always be a teacher present when groups are working.

CAN ANYTHING GOOD HAPPEN TO MY CHILD?

Yes, since the study aims to improve grade four learners' multiplication facts in areas where they are struggling, grade four learners might improve their multiplication facts and understand and enjoy mathematics more.

WILL ANYONE KNOW MY CHILD IS PART OF THIS STUDY?

The names of learners will not be linked to any part of the study, fake name or codes will be used. The data will be written into a report, but no child or school will be identified in the report.

WHO CAN MY CHILD TALK TO ABOUT THIS STUDY?

Learners can talk to their parents, teachers, principal or members of the SEDC team.

WHAT IF I DO NOT WANT MY CHILD TO DO THIS?

You are free not to allow your child to participate in this study, if the learner feels they do not want to participate in the study, they will not be asked to explain why not or get in trouble.

Please return

Child's name: _____

Parent's name: _____

Please circle your answers below:

- I understand the research study and my child may take part in it. YES NO
- Did the information answer my questions? YES NO
- I give permission to use the data gathered from this study. YES NO

_____ _____

Parent signature **Date**

APPENDIX G: LEARNER ASCENT FORM

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA
UFS UV

LEARNER INFORMATION LEAFLET AND ASSENT FORM

TITLE OF THE RESEARCH PROJECT: *How well can the SEDC team teach Grade 4 learners multiplication?*

.

RESEARCHERS NAME(S): Gerrit Johannes Cloete

ADDRESS: **60 Leo Cresent**
De Aar
7000

CONTACT NUMBER: 063 854 3230

What is RESEARCH?

Research is something we do to find new knowledge about the way things (and people) work Research also helps us to find better ways of helping learners learn mathematics.

What is this research project all about?

This research is about how well the SEDC group can teach Grade 4 learners their multiplication facts.

Why have I been invited to take part in this research project?

Grade 4 learners will write a test in the beginning of the project, this test will be looked at to see how best to help the learners. The SEDC team will then make a plan and teach the Grade 4 learners in small groups about multiplication. Then another test will be will be written to see how well the SEDC group taught the Grade 4 learners.

Who is doing the research?

The SEDC team will be doing the research to see if they can make teaching and learning multiplication in mathematics better.

What will happen to me in this study?

You will write a test in the beginning and a test at the end, between the tests you will work in a small group with a SEDC member once a week for half an hour, where you will learn about multiplication facts.

Can anything bad happen to me?

No, nothing bad can happen to you. The reason for the research is to find the best way to teach multiplication to Grade 4 learners.

Can anything good happen to me?

Yes, we will try to improve the areas where Grade 4 learners struggle with multiplication and it might make you understand multiplication better and like mathematics more.

Will anyone know I am in the study?

The names of learners or the school will not be used when writing about the research.

Who can I talk to about the study? *Learners can talk to their parents, teachers, principal or members of the SEDC team.*

What if I do not want to do this?

You are free not to take part in this study, if you feels you do not want to take part you will not be asked to explain why not or get in trouble.

Do you understand this research study and are you willing to take part in it?

YES NO

Has the researcher answered all your questions?

YES NO

Do you understand that you can pull out of the study at any time?

YES NO

_____ _____

Signature of Child Date

APPENDIX H: DECLARATION BY INTERPRETER

I *(name)* ……..…… declare that:

- I assisted the investigator (*name*) ……. to explain the information in this document to (*name of participant*) ……..…….. Using the language medium of Afrikaans/IsiXhosa.

- We encouraged him/her to ask questions and took adequate time to answer them.
- I conveyed a factually correct version of what was related to me.
- I am satisfied that the participant fully understands the content of this informed consent document and has had all his/her question satisfactorily answered.

Signed at (*place*) .....…….....…….. on (*date*) ……...……..

.....	.....
Signature of interpreter	Signature of witness

APPENDIX I: GR 4 TEST INSTRUMENT FRONT AND BACK

Naam/Name: _____ Totaal/Total: _____/33

Klas/ Class: Gr 4 ___ Skool/School: _____

Has the researcher explained the project clearly and answered all your questions?

Yes ☐ No ☐

Do you understand that you can withdraw from this project at any time?

Yes ☐ No ☐

Do you understand this research study and are you willing to take part in it?

Yes ☐ No ☐

_____ _____

Signature of child Date

Maaltafel Toets/Multiplication Test

Totaal/Total: _____/33

Bewerkings/Calculations

1 x 2 =	3 x 9 =
2 x 3 =	8 x 3 =
2 x 5 =	7 x 0 =
1 x 4 =	8 x 4 =
3 x 2 =	5 x 6 =
4 x 3 =	4 x 7 =
9 x 1 =	8 x 6 =
6 x 2 =	7 x 5 =
3 x 4 =	9 x 4 =
5 x 3 =	8 x 9 =
7 x 2 =	7 x 7 =
3 x 6 =	6 x 9 =
2 x 8 =	8 x 8 =
4 x 5 =	6 x 8 =
9 x 2 =	9 x 9 =
3 x 7 =	9 x 7 =
6 x 4 =	

APPENDIX J: LETTER FROM LANGUAGE EDITOR

TO WHOM IT MAY CONCERN

This is to state that the academic dissertation: 'A participatory community-based strategy…' (text only), submitted to me by Mr. G Cloete (student no. 2016255834) of the University of the Free State, South Africa, has been language edited by me, according to the tenets of academic discourse.

Mrs Carol Julia Keep, MA (English); BEd (Hons.); SOD; Cert. of Proofreading
Stirling Lodge
17 Epsom Rd.
Nahoon 5401
East London
South Africa

072 508 0936
caroljkeep@gmail.com

27 May 2024

C J Keep

APPENDIX K: PLAGARISM REPORT

GJCloete2016255834 PCBS TURNITIN text.docx

ORIGINALITY REPORT

8%	6%	4%	3%
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