The effect of a mathematical aided language stimulation programme for subtraction word-problem solving for children with intellectual disabilities

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Abstract

Children with intellectual disabilities are often denied exposure to mathematical word-problem solving since it is believed to beyond their intellectual abilities. This study aimed to determine whether children with intellectual disabilities could be taught to solve subtraction word-problems. The underlying premise of this study was that the receptive mathematical language skills of children with intellectual disabilities needed to be enhanced so as to optimize their word-problem solving abilities. This was undertaken through the implementation of a mathematical aided language stimulation programme (MAiLgS). This programme aimed to maximise exposure to and understanding of the mathematical language of word-problems for children with intellectual disabilities through simultaneous exposure to spoken input and visual supports. Two strategies were combined to form the MAiLgS programme. The first strategy referred to Goossens' (1989) principles of aided language stimulation whereby graphic symbols in the form of Picture Communication Symbols (PCS symbols) (Johnson, 1981) and spoken input were utilized to expound upon and clarify the vocabulary comprising word-problems. Riley, Greeno and Heller's model of word-problem solving (1983) was used to structure the three types of subtraction word-problems and to provide visual support in calculating the word-problem solutions. Seven children with intellectual disabilities aged between 8;0 and 12;0 were taught to solve the subtraction word-problems in a small group format. A multiple baseline design across behaviours (three types of subtraction word-problems) replicated across seven participants was used. The MAiLgS programme entailed teaching each of the three types of subtraction word-problems over a period of three weeks, with one word-problem type being taught each week. Participants' subtraction-word problem solving was monitored daily using probe tests. Three maintenance probes were conducted four weeks after intervention stopped. Four of the seven participants demonstrated improved subtraction word-problems solving for the three types of subtraction word-problems. The remaining three participants demonstrated minimal change in their ability to solve the word-problems. The results of this study suggest that a MAiLgS programme may be used in a small group format to teach word-problem solving to children with intellectual disabilities.

Keywords:

Aided input, aided language stimulation, augmented input, children, intellectual disabilities, mathematics, multiple baseline design, subtraction, visual supports, word-problem solving.

Opsomming

Kinders met intellektuele gestremdhede word dikwels nie blootgestel aan wiskundige woordprobleme nie, aangesien dit as bo hul intellektuele vermoëns beskou word. Die doel van hierdie studie was om te bepaal of kinders met intellektuele gestremdhede aftrek-woordprobleme geleer kon word. Die onderliggende uitgangspunt van hierdie studie was dat die reseptiewe wiskundige taalvaardighede van kinders met intellektuele gestremdhede versterk behoort te word om hul instaat te stel om hul woordprobleemoplossingsvaardighede te kan verbeter. Dit was bereik deur die implementering van ‘n wiskundige-taalgesteunde stimulasieprogram (MAiLgS). Die doel van hierdie program was om blootstelling aan en begrip van wiskundige taal wat in woordprobleme gebruik word, te vermeerder deur middel van gelyktydige blootstelling aan gesproke insette sowel as visuele ondersteuning. Twee strategieë is saamgevoeg om die wiskundige-taalgesteunde stimulasieprogram te ontwikkel. Die eerste strategie behels die taalgesteunde stimulasiebeginsels van Goossens’ (1989) waar grafiese simbole in die vorm van ‘Picture Communication Symbols’ (PCS) (Johnson, 1981) en gesproke taal gebruik was om die woordeskat wat in woordprobleme gebruik word, te verduidelik en te verklaar. Riley, Greeno en Heller (1981) se woordprobleemoplossingsmodel was gebruik om die woordprobleme te struktureer en om visuele ondersteuning te verskaf tydens die berekening van die oplossing van die woordprobleme. Sewe kinders met intellektuele gestremdhede tussen die ouderdomme van agt en 12-jaar het deel gevorm van die klein groep wat geleer was om aftrek-woordprobleme op te los. ‘n Veelvoudige basislynontwerp oor gedragsvorme heen (drie tipes aftrek woordprobleme) wat oor sewe deelnemers herhaal was, was gebruik. Die wiskundige-taalgesteunde stimulasieprogram het die aanleer van elk van die drie tipes woordprobleme oor ‘n periode van drie weke behels; waartydens een tipe woordprobleem per week aangeleer was. Die aftrek woordprobleemoplossingsvermoë van deelnemers was daagliks getoets. ‘n

Opvolgtoetse was uitgevoer vier weke nadat die intervensie gestaak was. Vier van die sewe deelnemers se vermoëns om die drie tipes aftrek woordprobleme op te los, het verbeter. Die ander drie deelnemers het minimale verandering in hul vermoë om aftrek woordprobleme op te los, getoon. Die resultate van hierdie studie dui daarop dat ‘n wiskundige-taalgesteunde stimulasieprogram gebruik kan word om woordprobleemoplossing aan kinders met intellektuele gestremdhede in ‘n klein groep aan te leer.

Kernwoorde:

aanvullende insette, aftrek, gesteunde insette, intellektuele gestremdhede, kinders, taalgesteunde stimulasie, veelvoudige basislynontwerp, visuele steun, wiskunde, woordprobleemoplossing.

CHAPTER 1

PROBLEM STATEMENT AND RATIONALE

1.1 Introduction

This chapter provides an overview of the study. It gives the rationale for the study and is followed by definitions of terms and abbreviations used in this study. Thereafter an outline of each chapter is included.

1.2 Problem statement and rationale

Mathematics is one of the academic subjects children study at school that facilitates their ability to solve problems. Within the mathematics curriculum, word-problems are specifically taught as they are considered to develop independent reasoning skills that can be used as a basis for children to employ their own ideas and problem-solving abilities in everyday situations (Krawec, 2014). However, word-problem solving has not been included in the mathematics curriculum for many children with intellectual disabilities, since these skills were purported to be beyond the intellectual capabilities of these children. The underlying assumption then is that these children could not be expected to solve problems of daily living. Instead, they received instruction in basic functional mathematical skills such working with money and time.

Research has shown that children both with and without disabilities who present with language and mathematical difficulties experience word-problem solving as perplexing. The challenge then is to address these difficulties within a learning context so that all children, including those with intellectual disabilities, are able to solve word-problems more competently. The difficulties that many children with intellectual disabilities experience with memory, encoding, retrieval and strategy employment, which affect their word-problem solving, are documented in various studies (Zheng, Swanson & Marcoulides, 2011).

Therefore, demystifying the language used in word-problems for children with intellectual disabilities is of paramount importance. Once the linguistic structure of word-problems is more meaningful, children with intellectual disabilities may be better able to understand the problem and in so doing create a suitable representation for it. This in turn can be expected to enable them to identify and employ the appropriate mathematical operations to solve the word-problems.

Various mathematical word-problem solving models have been developed that take linguistic and/or mathematical difficulties into account and try to compensate for them. The model of Riley, Greeno and Heller (1983, 1988) is a renowned model that requires increasingly complex levels of skill to solve addition and subtraction word-problems using three different types (change, combine and compare). Although its application to children with intellectual disabilities appears to be lacking to date, this model seems to provide flexibility in terms of the levels of skill that can be used and as such may be effective in teaching these children. It is important to acknowledge, however, that other difficulties that are experienced by children with intellectual disabilities, such as attention and concentration lapses or physical barriers, need to be accommodated when using this model.

The multistore models of Paivio (1980) and Baddeley (1992) refer to the operationalisation of nonverbal (pictures or symbols) and verbal (spoken words) input. Using a strategy which simultaneously taps these forms of input may be effective in enhancing word-problem solving for children with intellectual disabilities. One such strategy is augmented input, referred to in the field of augmentative and alternative communication, in which the comprehension of spoken input is enhanced by the use of Augmentative and Alternative Communication (AAC) (Lloyd, 1997).

Augmented or aided input is a well-documented part of the AAC field, although it is typically viewed as a strategy to enhance expressive communicative ability. Various aided input strategies have been developed, which include aided language stimulation (AiLgS), a variation of a “verbal language stimulation approach” to replicate natural speech patterns that facilitate comprehension of the language (Goossens’, 1989, p.16). Literature pertaining to AiLgS discusses its application in improving communication as well as enhancing the receptive language skills of children with little or no functional speech. Application of AiLgS to enhance input during mathematics and word-problem solving specifically, however, appears to be absent in the published literature.

The supposition for this study is, therefore, that AiLgS principles can be applied within a mathematical word-problem solving context using the model of Riley et al. (1983). This entails pointing to a graphic symbol (Picture Communication Symbol or PCS) and verbalising the word-problems simultaneously according to the frequency and nature prescribed by Goossens’ (2000).

Accordingly, the main aim of this study is to determine the effect of a three-week-long MAiLgS programme on three types of subtraction word-problem solving skills with children with intellectual disabilities.

1.3 Terminology

The following terminology is used frequently in this study and is, therefore, clarified.

1.3.1 Aided Language Stimulation

Aided Language Stimulation (AiLgS) refers to a strategy whereby spoken linguistic input is combined with the use of AAC. Accordingly, in this study, the facilitator points to PCS symbols on a facilitator board while simultaneously providing continuous spoken input for 80% of the spoken words, in the ratio of 80:20 for statements: questions (Dada & Alant, 2009; Goossens', 2000). The facilitator board adheres to a prescribed set-up, namely:

i) PCS symbols were arranged in accordance with the structure of the Fitzgerald key.

ii) The symbols were arranged in a 36-matrix and colour coded according to Goossens' convention.

iii) The PCS symbols were printed in colour.

iv) Gloss was included above the PCS symbols to expose participants to the text incidentally. This also ensured that the gloss was not covered when the symbols were pointed to.

v) The background of the facilitator board was board was black to avoid visual distraction.

1.3.2. Calculation mats

The calculation mats were included as part of the facilitator board to calculate word-problem answers and took the form of one red and one purple rectangular shape, each labelled with the characters used in the word-problems (Zinzi and Joe). The participants each had an A3 replica of the facilitator board, and the calculation mats on this replica measured

170mm x 115mm. The participants were able to perform their word-problem solving calculations on the calculation mats.

1.3.3 Intellectual disability

Intellectual disability refers to deficits in general mental functioning that lead to difficulties in adaptive functioning. Individuals with intellectual disabilities do not meet conventional standards of personal independence and social responsibility with regard to communication, social participation and academic functioning (American Psychiatric Association. Diagnostic and statistical manual of mental disorders, 2013). The severity of the intellectual disability is specified as being mild, moderate, severe or profound (DSM-5, 2013). In this study intellectual disability was specifically used in relation to an intelligence quotient (IQ) of less than 70 and more than 40, which is described as being a "moderate" intellectual disability (DSM -5, 2013).

1.3.4. Manipulatives

Manipulatives were used to work out the solutions to the word-problems. They were used by the facilitator during the intervention programme and each participant had 20 at their disposal during probe tests. The manipulatives were transparent, flat-based, convex glass objects that measured 20mm in diameter.

1.3.5 Mathematical Aided Language Stimulation (MAiLgS)

Mathematical aided language stimulation is a term coined for this study. It refers to providing AiLgS for mathematical word-problems, whereby spoken input is enhanced by the facilitator pointing simultaneously to the corresponding PCS symbols on a facilitator board. The solution process is also modelled using manipulatives.

1.3.6 Picture Communication Symbols (PCS symbols)

The Picture Communication Symbol set was developed by Johnson (1981) and consists of line drawings that depict various themes (Tönsing, Alant & Lloyd, 2005). The PCS symbols were specifically selected for this study given their common use in the South African context (Bornman, Bryen, Kershaw & Ledwaba, 2011; Dada, Huguet & Bornman, 2013; De Klerk, Dada & Alant, 2014; Haupt & Alant, 2003). Within this symbol set, plump figures as opposed to stick figures printed in black were used. These were printed on coloured backgrounds according to Goossens' stipulations, although a grey background was used for numerals. For this study some of the symbols were adapted to better suit the word-problem teaching. The gloss was positioned at the top of each symbol so it was not obstructed by the facilitator's hand when pointed to. The gloss was included on the symbols to give the children the potential benefit of print exposure, which could enhance incidental learning.

1.3.7 Word-problems

In this study word-problems refer to mathematical word-problems that focus on subtraction and specifically three types, namely change, combine and compare word-problems. They comprise word-problems that are presented in story form and require an arithmetic solution.

1.4 Abbreviations

The following abbreviations are used in this study.

A3	Paper size that measures 297mm x 420mm
AACIF	Augmentative and Alternative Communication Input Framework
AAC	Augmentative or Alternative Communication
ADHD	Attention Deficit Hyperactivity Disorder
AiLgS	Aided Language Stimulation
ALM	Aided Language Modelling
ASD	Autism Spectrum Disorder
CI	Confidence Intervals
DD-SGD	Dynamic Display Speech-Generating Device
DV	Dependent Variable
HPCSA	Health Professions Council of South Africa
IV	Independent Variable
IQ	Intelligence Quotient
IRD	Improvement Rate Difference
IR_B	Improvement Rate of the Baseline phase
IR_T	Improvement Rate of the Treatment (Intervention) Phase
K-Bit 2	Kaufman Brief Intelligence Test – Second Edition
LeSTE	Learner Screening Tool by Educators
LoLT	Language of Learning and Teaching
LSEN	Learner having Special Educational Needs
MAiLgS	Mathematical Aided Language Stimulation
OWLS-II	Oral and Written Language Scales – Second Edition
PCS	Picture Communication Symbols
PND	Percentage of Non-overlapping Data

PPVT-IV	Peabody Picture Vocabulary Test – Fourth Edition
WIAT-II	Wechsler Individual Achievement Test – Second Edition

1.5 Notation

In this study the convention for representing the aided language stimulation used during the MAiLgS programme adhered to the guidelines described by Von Tetzchner and Basil (2011) which are advocated for the AAC Journal. Accordingly, the gloss of graphic symbols used were both italicized and typed in capital letters (e.g. *SWEETS)* and naturally spoken utterances were typed in italics (e.g. *I am sure that he would like it*). For the simultaneous production of spoken words and graphic symbols, waved brackets were also used (e.g. {*SWEETS sweets}).*

1.6 Chapter overview

This study comprises seven chapters. Chapter 1 includes a basic orientation to and justification for the study. The terminology and abbreviations used in this study are shown, followed by an outline of the chapters.

Chapter 2 presents the literature and research that elucidate upon mathematical word-problem solving for typically developing children so as to inform practice for children with intellectual disabilities. Four models of word-problem solving are considered, together with two developmental views of word-problem solving. Pedagogical considerations of teaching word-problem solving related to educational trends and teaching strategies that may be used for children with intellectual disabilities are then discussed. Thereafter, dual processing models that may potentially be used for word-problem solving are discussed. Augmented input, specifically relating to aided input that falls within the field of AAC, is described for its potential application to teaching word-problem solving to children with intellectual disabilities.

The methodology of this study is described in Chapter 3. The main and subaims of the study are presented, followed by a description of the research design and phases. Thereafter, the pilot studies in terms of the objectives and methods, which include procedures and measures, results and recommendations, are presented. A description of the participants, data collection methods and data analysis procedures that were employed during the main study are then provided. Finally, reliability concerns for this study are discussed.

Chapter 4 describes the MAiLgS programme developed for this study. The respective contributions to the programme are explained: they include an adapted version of the AACIF (Wood, Lasker, Siegel-Causey, Beukelman & Ball, 1998), principles of AiLgS (Goossens', 1989, 2000) and the word-problem solving model of Riley et al. (1983).

In Chapter 5 the results of this study are presented. Firstly, the procedural integrity and reliability of data is discussed. This is followed by a description of the frequency and nature of AiLgS. Secondly, to determine the effect of the MAiLgS programme on the subtraction word-problem solving of children with intellectual disabilities, two analyses are used. The first analysis involves the data for each participant being presented graphically and a visual analysis is provided in terms of the level, trend and variability, immediacy of effect and consistency of phases. The second analysis is a statistical analysis of the data presented using the percentage of non-overlapping data (PND) and improvement rate difference (IRD).

The focus of Chapter 6 is on a discussion of the results obtained in this study. Relevant literature is referred to in order to explore factors that may influence the results in terms of internal (participant) and external (intervention) factors.

Chapter 7 presents a summary of the study. This is followed by an evaluation of the study in terms of its strengths and limitations. The clinical implications of the study are discussed, followed by recommendations for future research.

1.7 Conclusion

This chapter provided the rationale for the study of teaching subtraction word-problem solving to children with intellectual disabilities using an MAiLgS programme. A description of the terminology and abbreviations used in this study followed. An outline of the chapters concluded this chapter.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The aim of this chapter is to explore the factors that impact on mathematical word-problem solving for children with intellectual disabilities. The research and literature contributions that could elucidate how mathematical word-problem solving can be facilitated by graphic symbol input in the form of aided language stimulation for children with intellectual disabilities are considered. The discussion begins by considering the importance of mathematics as a subject in which skills for daily living are developed for children with intellectual disabilities. Next, word-problem solving in terms of development is presented. Four models of word-problem solving representation are reviewed, together with two developmental views of word-problem solving. Thereafter pedagogical considerations of teaching word-problem solving related to educational trends and teaching strategies are presented. Subsequent to this, multistore models that may potentially be used for word-problem solving are discussed. The chapter ends with a discussion about aided input that falls within the field of AAC, given its potential application to teach word-problem solving to children with intellectual disabilities where a multistore model is operationalised. Figure 2.1 presents a graphic representation of the theoretical constructs addressed in this chapter that highlights their inter-relatedness.

2.2 Mathematics for children with intellectual disabilities

Intellectual disability was previously regarded as an innate attribute of the person. This view had far-reaching effects in the field of education, where children with intellectual

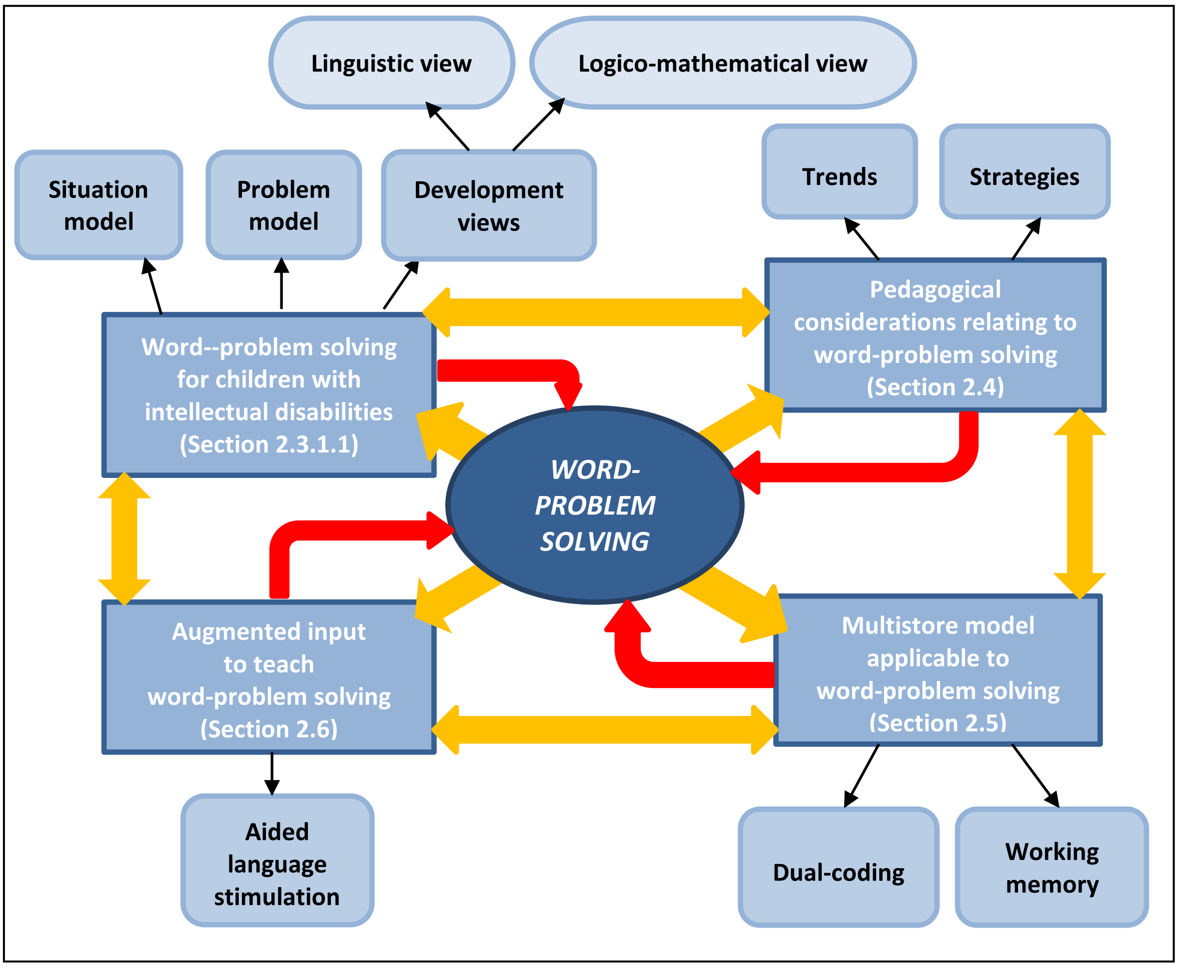

Figure 2.1 Graphic representation of the theoretical constructs addressed in this chapter

disabilities were denied equal learning opportunities due to the exclusionary nature of the medical model (Naicker, 1999). Accordingly, the focus of mathematics at school was on elementary skill acquisition rather than application of problem-solving skills in situations of daily living (Alfassi, Weiss & Lifshitz, 2009; Browder, Gibbs, Ahlgrim-Delzell, Courtade, Mraz & Flowers, 2009; Fuchs & Fuchs, 2005; Taber-Doughty, Bouck, Tom, Jasper, Flanagan & Bassette, 2011).

It is, therefore, imperative to consider how children with intellectual disabilities may be empowered to employ the basic mathematical problem-solving processes and knowledge that would enable them to cope with daily living tasks at home, at school and within the community (Barnett & Ceci, 2002; Briars & Larkin, 1984; Cassel & Reid, 1996; Jiménez &

Verschaffel, 2014; Kelly & Mousley, 2001; Jitendra, Rodriguez et al., 2013; Knifong & Burton, 1985; Ma & Zhou, 2010; Rosales, Vicente, Chamoso, Muñez & Orrantia, 2012; Schliemann & Carraher, 2002; Xin, Jitendra & Deatline-Buchman, 2005).

2.3 Word-problem solving for children with intellectual disabilities

Mathematical word-problems are characterised as being "linguistically presented problems requiring arithmetic solutions" (Zheng, Flynn & Swanson, 2013, p. 97). Given the complex nature of word-problems, literature suggests that word-problem solving is an area of concern for many children, both with and without intellectual disabilities (Burton, n.d.; Cassel & Reid, 1996; Jaspers & Van Lieshout, 1994; Jitendra, Griffin, McGoey, Gardill, Bhat & Riley, 1998; Owen & Fuchs, 2002; Parmar, Cawley & Frazita, 1996; Reikarås, 2006; Zheng et al., 2011). This is because word-problems require children to understand the wording of the word-problems, represent the mathematical components accurately, plan and solve the solution strategy and retrieve answers from memory, (Jitendra et al., 2013; Jitendra, Rodriguez et al., 2013). Since there appears to be a paucity of literature pertaining to word-problem solving development for children with intellectual disabilities, it would be worthwhile to explore the development of word-problem solving in typically developing children, given that children with intellectual disabilities may progress through the same phases albeit at a slower rate (Piaget & Inhelder, 1966, 1969).

2.3.1 Development of word-problem solving

For many typically developing children word-problem solving is likely to be challenging, making this task equally if not more challenging for children with intellectual disabilities. Regardless of the model used to teach word-problem solving, the goal needs to be to equip children with intellectual disabilities with skills that promote mathematical learning and the ability to still apply this in real-world situations (Rosales et al., 2012).

2.3.1.1 Word-problem models

The word-problem solving model proposed by Mayer in 1985 (cited in Krawec, Huang, Montague, Kressler, & De Alba, 2012) may be ineffective for children with intellectual disabilities due to its complexity. It comprised four sequential phases in which correct solutions were dependent on calculation accuracy (Jitendra, Griffin, Deatline-Buchman & Sezesniak, 2007). As a result, a calculation error in the first phase negated successful solution in the subsequent phases.

Instead, a schema-based model of teaching word-problems which has proven successful for children with learning disabilities may be effective for children with intellectual disabilities. This model of instruction requires children to create mental representations of the word-problems, which are purported to facilitate the encoding of the information required to solve the problem (Brissiaud & Sander, 2010; Jitendra et al., 2007; Kintsch & Greeno, 1985; Rosales et al., 2012; Thevenot, 2010; Tolar et al., 2012; Xin et al., 2005; Zheng et al., 2013). The mental representations facilitate the encoding of the word-problem information, since essential information within the word-problem is distinguished from non-essential information (Rosales et al., 2012). When creating mental representations of the word-problem, two distinct yet overlapping situation and problem models result (Tolar et al., 2012).

The situation model is closely aligned to real-world experiences and events since it uses the spoken form of the word-problem to generate a conceptual representation that can be used as the basis for solving the word-problem (Kintsch & Greeno, 1985). The problem or mathematical model is more reliant on problem-solving experiences as well as the teaching of word-problem solving. For this reason, this model is composed of mental representations that only encompass those elements that are central to solution and are more mathematical in nature (Tolar et al., 2012). Once the situation and problem models have been created, the result is that mathematical and real-world knowledge, learned and incidental experiences and mental procedures in the form of procedures or inferences are operationalised (Tolar et al., 2012).

In children with intellectual disabilities the link between the situation and problem models may not be apparent. This could result in the situation model assuming the dominant role due to the story embedded in the word-problem triggering viable informal solution strategies that are more accessible (Tolar et al., 2012). Inaccurate mental representations in the problem model occur when there are misconceptions or deficiencies within the conceptual knowledge bases of children that result in errors (Verschaffel & De Corte, 1993). It is important to bear in mind that these conceptual knowledge bases can assume one of two forms, depending on the development view subscribed to.

2.3.1.2 Development views of solving word-problems

The first view is the linguistic development view (Cummins, Kintsch, Reusser & Weimer, 1988; Cummins, 1991). Since it is argued that mathematics may be considered a language in itself (Aiken, 1971; Burton, n.d.; Cuevas, 1984; Furner, Yahya & Duffy, 2005; Ma & Zhou, 2010; McKenzie, 2001; Miller & Mercer, 1997; Schleppegrell, 2007; Thorndike, 1912) this view holds that the linguistic forms that children employ to solve word-problems need to map onto their existing knowledge accurately.

What distinguishes mathematical language from everyday language has to do with the way in which language is used in learning mathematics (Schleppegrell, 2007). In keeping with the linguistic developmental view, difficulties with word-problem solving can be attributed to the linguistic form of the word-problem not being mapped onto existing structures within the child's knowledge (Cummins et al., 1988). Accordingly, comprehension and solution of word-problems is influenced (Cummins et al., 1988; Hall, Kibler, Wenger & Truxaw, 1989). During the comprehension phase, children process the word-problem text and then have to create an internal representation in terms of the quantities and relationship between constructs (Koedinger & Nathan, 2004). This is reflected in studies that found that the underlying semantic structures of subtraction word-problems strongly influenced how children solved them (Carpenter & Moser, 1982, 1984; De Corte & Verschaffel, 1987; Jaspers & Van Lieshout, 1987; Schleppegrell, 2007). It is, therefore, believed that understanding the word-problem may better enable children to represent it correctly and consequently select appropriate solution strategies (Schumacher & Fuchs, 2012). The solution phase thus entails the transformation of the internally represented and externally presented quantitative relationships (Koedinger & Nathan, 2004).

When working through word-problems, children's level of language development needs to enable them to understand the word-problems in order for the comprehension phase to be operationalised (Purpura, Hume, Simms & Lonigan, 2011). Language difficulties may result in children experiencing confusion with identifying the operation to be used to solve the word-problems, since terminology may have multiple meanings (McKenzie, 2001; Purpura et al., 2011, Rupley, Capraro & Capraro, 2011). Traditional teaching of word-problem solving through the identification of key words that imply the appropriate operation (Jitendra et al., 2007) may thus be negated by language challenges. The implication is that a very specific mathematical meaning needs to be associated with a given term so as to avoid confusion and thus incorrect problem solving. The goal is, therefore, to support children in understanding the vocabulary of word-problems well enough to solve them. Essentially, language that is on the functional level of the children should be used to ensure that their word-problem solving is not disadvantaged by unfamiliar vocabulary. Accordingly, for word-problem solving to be effective, the word-problem semantic structure must be explicit (Verschaffel & De Corte, 1993).

This can be done by varying the wording of word-problems by using words that are more familiar to children (Koedinger & Nathan, 2004). In so doing children are supported in creating a more accessible version of the word-problems: a strategy that is suggestive of the use of scaffolding within the social constructivist view, which describes the "process that enables a child or novice to solve a problem, carry out a task or achieve a goal which would be beyond his unassisted efforts" (Wood, Bruner & Ross, 1976, p. 90). Scaffolding is informed by the zone of proximal development developed by the social constructivist theorist Vygotsky. It is a metaphor which describes "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1978, p. 86). Within the linguistic development view this would entail teachers assuming the role of a facilitator to support children with intellectual disabilities to understand the vocabulary of the word-problems.

The second view is the logico-mathematical view (Cummins et al., 1988; Cummins, 1991), which was a focus of the work done by Jean Piaget considered to be a guide regarding the order in which mathematical concepts are taught (Riley & Greeno, 1988). The main premise of Piaget's work is that development follows a set sequence through which children progress, albeit at different rates (Brennan, 1998; Ojose, 2008; Piaget & Inhelder, 1966/1969). According to the Piagetian framework, children battle to solve word-problems because they have not yet developed the skills required for the given word-problems (Cummins et al., 1988). This argument lends itself to Piaget's four stages of development: the sensory-motor, pre-operations, concrete operations and formal operations stages (Piaget, 1964). The implication is that if children have not progressed to the stage of development that would equip them with the skills required to solve a given word-problem, they would be unable to find a solution.

Central to this view is the need for knowledge relating to part-whole relationships to be established (Verschaffel & De Corte, 1993). As a result, when children are unable to solve word-problems this may be attributed to insufficient knowledge relevant to the word-problems (Cummins, 1991). For many children with intellectual disabilities this may be because the knowledge is not part of their existing knowledge base, which according to Jerome Bruner can assume one of three forms. The enactive mode requires manipulation of concrete apparatus, the iconic mode involves the interpretation of pictures and graphs and the symbolic mode uses symbolic information such as numerals (Pape & Tchoshanov, 2001; Witzel, Mercer & Miller, 2003).

While these two views operationalise different skills, research appears to be more supportive of the linguistic development view given that the study conducted by De Corte, Verschaffel and De Win (1985) produced improved results when the linguistic structure of word-problems were manipulated (Cummins et al., 1988). This is because minor changes to the wording of word-problems can result in accurate solutions, as children can be expected to simplify the wording of the word-problems to a more a familiar linguistic form (Cummins et al., 1988). The conceptual knowledge required within the logico-mathematical development view cannot, however, be adapted, thereby complicating problem-solving further (Cummins et al., 1988). It is thus contended that employing the linguistic development view while solving word-problems may be most effective for children with intellectual disabilities. Accordingly, the most effective teaching strategies employing the linguistic development view need to be identified.

2.4 Pedagogical considerations of teaching word-problem solving

2.4.1. Educational trends in teaching children with intellectual disabilities

Van Garderen, Scheuermann, Jackson and Hampton's (2009) research overview offers insightful information in terms of trends in education regarding children within both mainstream and special education. Their overview reveals that within special education specifically, 61% of the 31 studies reviewed drew upon cognitivism, 23% upon behaviourism and 16% upon socioculturalism. Research conducted by Van Luit and Naglieri in 1999 focused predominantly on children with intellectual disabilities. Their research found that these children benefitted most from the application of behaviourist principles, while van Garderen et al (2009) did not draw conclusions as to the effectiveness of the trends identified.

2.4.2 Teaching strategies for children with intellectual disabilities

Regardless of the type of strategy advocated for children with intellectual disabilities, the goal must be to equip them with skills that promote mathematical learning and the ability to apply this learning in real-world situations (Rosales et al., 2012). Limited exposure to basic arithmetic skills alone, however, would fail to achieve the goal for children with intellectual disabilities. Instead, problem-solving skills that have a more pervasive effect in children's lives need to be explored. According to Reikerås (2006), research on mathematics is typically directed at typically developing children experiencing a specific mathematics disorder, also referred to as dyscalculia, with regard to their counting abilities. The available research regarding mathematics and children with intellectual disabilities is, however, more limited and ascertaining the best way to teach mathematics to them has clearly been characterised by considerable debate within the educational field. The research that has been done nonetheless reveals that the higher-level cognitive skills required for word-problem solving are often beyond the capabilities of children with intellectual disabilities, despite their value in everyday situations (Grové & Hauptfleisch, 1993; Kroesbergen & Van Luit, 2005; Parmar, Cawley & Miller, 1994; Sileo & Van Garderen, 2010). Research has nonetheless found that a limited number of strategies should be taught to children with intellectual disabilities due to the difficulties they experience with commanding a large number of options (Gersten, Chard, Jayanthi, Baker, Morphy & Flojo, 2009; Van Luit & Naglieri, 1999). Fervent opposition to this direct instruction is also evident. It is postulated that teaching children with intellectual disabilities specific steps will result in them becoming focused on doing the steps correctly, thus losing the focus of the activity (Woodward & Montague, 2002).

To explore this area of contention, the literature reviews of Butler, Miller, Lee and Pierce (2001) and the meta-analysis of Kroesbergen and Van Luit (2003) seem to expound upon effective teaching strategies for children with intellectual disabilities. Butler et al.'s literature review (2001) focuses specifically on types of mathematics intervention for children with mild to moderate intellectual disabilities, while Kroesbergen and Van Luit's meta-analysis (2003) examines mathematics intervention used for children who may be considered as having special needs. While Butler et al. (2001) note a shift to teaching problem solving; the emphasis in the studies they reviewed was on specific techniques that could be used regardless of the topic being taught. It is important to observe the apparent absence of word-problems in the foci of studies reviewed by Kroesbergen and Van Luit. However, the teaching practices identified as effective for children with intellectual disabilities in these reviews may provide insight and guidance on teaching word-problems.

Butler et al. (2001) focused on 16 studies in their literature review. Three search criteria were used to select these studies. Firstly, only studies published between 1989 and 1998 were considered. Secondly, teaching mathematics to children with intellectual disabilities had to be the focus of the studies, but those that taught money skills to children with intellectual disabilities were excluded. Finally, studies that addressed intellectual disabilities were included as opposed to those in which cross-categorical terms such as “mildly disabled” were used to describe participants. In total, 271 children were included in the 16 studies. Research designs included group comparison in four of the studies, while 12 studies used single subject designs. Elementary schools were used in 13 of the studies; high schools were used in two studies and only one study made use of special schools. The specific mathematical concepts covered by these studies included basic mathematical skills, teaching methods used to teach computational skills and problem solving. Two conclusions can be derived from this review. Firstly, the emphasis in mathematics for children with intellectual disabilities has changed over time from learning basic skills and computations to problem solving. Secondly, children with intellectual disabilities seem to benefit most from explicit instruction, regular feedback and considerable practice.

In their meta-analysis, Kroesbergen and Van Luit (2003) included 58 studies that explored types of mathematical intervention that were published between 1985 and 2000.

These authors included studies that met the following five criteria. The first criterion dictated that only studies that explored elementary mathematics skills and thus focused on children who were younger than 12;0 be included. The second criterion required a report on an intervention that involved mathematical instruction. The third criterion was related to the mathematical difficulty that the children experienced. As such, children who were at risk for disabilities, lagging behind, presenting with mathematical learning disabilities, “educable”, or who presented with mild intellectual disabilities were included. However, children who experienced mathematical difficulties as a result of severe intellectual disabilities were excluded. The fourth criterion stipulated that only studies that used between-subjects or within-subjects control conditions and included more than three subjects could be used. The fifth criterion dictated that interventions had to describe the systematic use of instructional strategies. This meta-analysis revealed that larger effect sizes were obtained with single-subject designs that used shorter interventions. Interventions focused on word-problem solving appeared to be less effective than those focusing on preparatory arithmetic or basic mathematical facts, hence reinforcing the need for further research in this area. Moreover, self-instruction was identified as being more effective than both direct instruction and mediated instruction. The information gleaned from these studies may be applied to the teaching of word-problems to children targeted within the meta-analysis, including children with mild intellectual disabilities. The meta-analysis suggests that children cope better with word-problem solving when they are able to solve the word-problems using their own language.

The paucity of research regarding the teaching of word-problem solving for children with intellectual disabilities is evident from the reviews discussed above. As a result, studies that are applicable to this area had to be located and an electronic database search was thus conducted. Figure 2.2 presents the PRISMA flow diagram which delineates the process used to identify suitable studies. The four search engines that were used to identify the studies included Google Scholar, Ebscohost ERIC, Informa Healthcare and JSTOR. The descriptors that refined the search included “mathematics for children with intellectual disabil*”, “word-problem solving”, “maths word-problems”, “word-problem skills”, “problem-solving”, “story sum*”, “subtract* word-problems”, “teaching word-problems”, “instructional strategies” and “mathematics learning”. The inclusion criteria dictated that the studies used had to be conducted after 2000 to avoid replication of those identified by Butler et al. (2001) and Kroesbergen and Van Luit (2003), which focused on studies to 2000. Secondly, only studies that contained empirical data and described intervention strategies were considered. Thirdly, the studies had to include word-problem solving teaching interventions. Finally, studies exploring the teaching of word-problems for children with intellectual disabilities specifically were selected.

The search registered 289 papers. Each of these papers was worked through at the abstract level and evaluated in terms of its relevance to children with intellectual disabilities solving mathematical word-problems. Exclusion criteria used were that studies that reflected variations of the descriptors used were to be excluded. This resulted in 57 studies being excluded. Thirty-six papers that were discussion-based were also excluded. The 47 studies that focused on physical or other disabilities were also eliminated. Fifty-eight studies that explored the teaching of mathematical concepts not related to word-problems were also excluded. Fifty-two studies that focused on mathematical learning disabilities (dyscalculia) were excluded. Furthermore, six studies that examined emotional factors inhibiting word-problem solving were not considered. The 21 studies addressing word-problem solving in

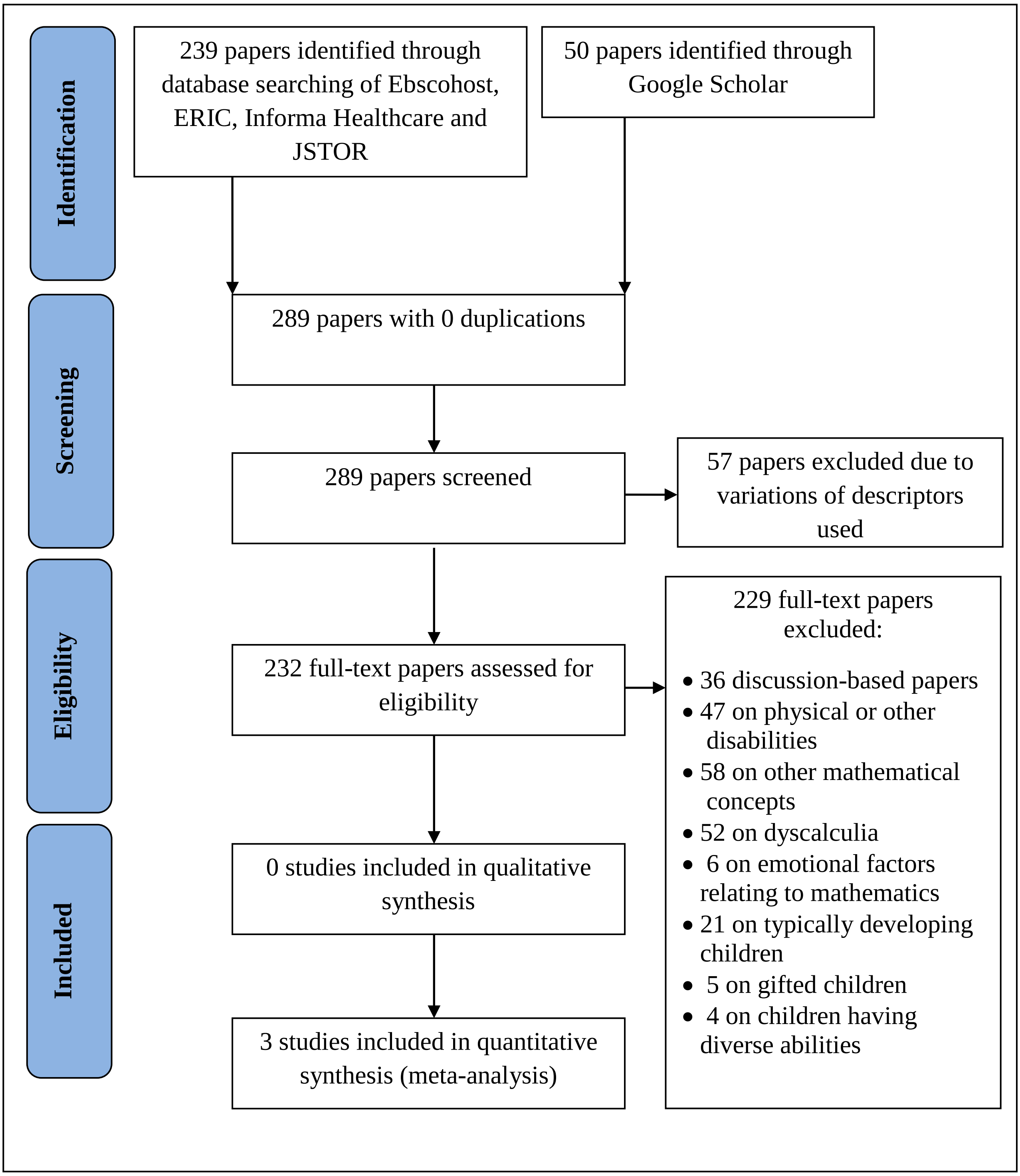

Figure 2.2 PRISMA flow diagram delineating the process used to identify suitable studies (taken from Moher, Liberati, Tetzlaff & Altman, 2009).

typically developing children, five that involved word-problems for gifted children and four that examined word-problems in children with diverse abilities were also excluded.

The remaining three studies met the inclusion criteria. They were considered for their focus on exploring teaching interventions that may be effective in teaching mathematical word-problem solving to children with intellectual disabilities. Table 2.1 describes these studies and provides pertinent implications for this study. Rockwell, Griffin and Jones (2011) used a single-subject design, Chung and Tam (2005) used a cross-subjects experimental design while Owen and Fuchs (2002) used a pretest-post-test design. The limitation of each of these studies was the small sample used, which may affect generalisability to the larger population of children with intellectual disabilities (Milo, Seegers, Ruijssenaars-Wied & Vermeer, 2004).

Each study's intervention effectiveness could be determined since participants were tested both prior to and following intervention. Chung and Tam (2005) and Rockwell, Griffin and Jones (2011) extended this exploration further since they retested the participants after a period of time. Owen and Fuchs (2002) included a novel element to their study that is not evident in the other studies identified, in that participants were required to evaluate their experience of the intervention. All three studies included a focus on specific teacher-driven teaching, since they succinctly explored how children could learn word-problem solving, and various step-type strategies were thus used. While identifying effective teaching interventions that promote mathematical word-problem solving for children with intellectual disabilities is imperative, it would be remiss to overlook the ways in which the children receive the teaching intervention. Accordingly, in order to promote understanding and retention for children with intellectual disabilities who experience memory or organisational thinking

Table 2.1 Three studies that focused on teaching interventions for mathematical word-problem solving in chronological year order

Author & Date	Aim	Participants	Design	Procedure	Instructional Strategy	Results	Implications for current study
Owen & Fuchs 2002	To examine the effects of strategy instruction on problem solving with third-grade children with intellectual disabilities	24 third-grade children (20 with learning disabilities, 2 with speech/language disorders, one with mild/moderate intellectual disability and 1 with attention deficit hyperactivity disorder)	Pretest – post-test	During the pretest 4 problems were presented to children. In the intervention phase children were exposed to 1 of 4 conditions (control, acquisition, low-acquisition plus transfer or full-acquisition plus transfer). A post-test was conducted to find the number of correctly answered problems. Thereafter, each child and a partner completed a survey to elicit opinions about the intervention and working with a partner. The teachers of the children also completed surveys regarding the intervention's effectiveness in terms of meeting the needs of their children and whether working with partners improved their performance.	Participants in the experimental group were exposed to instruction using a 6-step procedure for solving word-problems. Explicit instruction included intensive worked examples and practice with a participant who was achieving on a higher mathematical level.	A significant 2-way interaction between time and treatment was noted [$F(3,20)=9.57, p<.001$], which indicated differences in growth as a result of treatment. The children's performance on measures of using taught strategies correctly and finding correct answers to problems increased when they were taught the given strategy. They also performed better than their peers who received conventional instruction.	Since teaching a given strategy proved to be successful in this study, it is hypothesised that teaching a strategy to solve word-problems to children with intellectual disabilities will reveal similar results in the current study.

Table 2.1Three studies that focused on teaching interventions for mathematical word-problem solving in chronological year order cont.

Author & Date	Aim	Participants	Design	Procedure	Instructional Strategy	Results	Implications for current study
Chung & Tam 2005	To examine the effects of different approaches to teaching children with mild intellectual disabilities to solve word-problems	30 children with mild intellectual disabilities, of Chinese descent	Cross-subject experimental design	Tasks were taken from questions used in mathematics textbooks for grades 1 and 2. They took the form of two-step addition and subtraction word-problems. 3 phases – instructional, acquisition and test phases – were used. The first two phases were done during 5 regularly scheduled classes. The test phase followed immediately and a delayed test was conducted 2 weeks later.	The instructional phase included exposure to concepts such as “more than” and “less than”. The acquisition phase entailed a set of 5 problems for each session. Two problems were used as worked examples and 3 were given to the children to solve. This included exposing the children to the convention instructional group (CO), worked example group (WE) or cognitive strategy group (CS).	The mean correct scores (maximum possible score was 24) for each group in the immediate and delayed tests: CO group (n=10) scored 13.80 in the immediate test and 9.90 in the delayed test. WE group (n=10) scored 16.70 in the immediate test and 16.80 in the delayed test. CS group (n=10) scored 16.50 in the immediate test and 17.20 in the delayed test. Results indicate that children could solve more word-problems correctly if they followed worked examples and were exposed to cognitive strategy instruction. Their ability to generalise and maintain skills and knowledge increased.	The WE used as a component of this study evidently enabled children to complete word-problems accurately. As a result, a variation of this will be employed in the current study in an attempt to enable children to solve word-problems more accurately. The number of questions used for examples and test item appears to have been effective and may be used as a guide in this study.
Rockwell, Griffin & Jones 2011	To explore a schema-based strategy instruction in teaching word-problems for addition and subtraction to a fourth grade child with autism	One 10-year-old female with autism who demonstrated below-average verbal and nonverbal intellectual abilities.	Single-case, multiple probe across behaviours	The intervention was conducted over an 8- week period, four times per week, which totalled 540 minutes. The first 45 minutes of the 2-hour sessions were devoted to scheme-based strategy instruction. The remainder of the sessions were filled with other academic activities.	Direct Instruction was used to teach a 4-step heuristic for problem solving using the RUNS mnemonic (Read the problem, Use a diagram, Number the sentence & State the answer) was taught to the participant. The steps of the RUNS mnemonic were based on the FOPS mnemonic (Find the problem type, Organise the information in the diagram, Plan to solve the problem & Solve the problem). Problem types were separated to enable the participant to familiarise herself with the schematic diagrams.	Improvement in the participant’s ability to solve each type of 1-step addition and subtraction word-problems. Generalisation to word-problems with unknown variables in different positions was noted.	Direct instruction facilitates word-problem solving and will thus be used in this study. Separating problem types also presents as being effective and justifies working through the 3 types of word-problem used in this study.

difficulties, the processing of information needs to be explored (Miller & Hudson, 2006; Donaldson & Zager, 2010).

2.5 Multistore theories that are applied in word-problem solving

Multistore theories that have been developed to explain how information is processed include the multistore stage model of Atkinson and Shiffrin (1968), the levels of processing model of Lockhart and Craik (1972, 1994), the dual coding theory of Paivio (1980, 1986, 2006), Baddeley's working memory model (1992, 2000, 2003) and Engelkamp's multimodal theory (1998). The processing models can explain how children with intellectual disabilities may experience memory and processing demands. They may further facilitate understanding of how support strategies could enhance these processes to assist with solving mathematical word-problems.

2.5.1 The effect of processing on word-problem solving

The dual-coding theory of Paivio (1980, 1986, 2006) is specifically explored for its potential contribution to understanding how children with intellectual disabilities solve word-problems. Paivio sees human cognition as consisting of two "interconnected but functionally independent systems" (Paivio, 1980, p. 296) in which information is thought to be processed along visual (nonverbal) and auditory (verbal) channels (Carbonneau, Marley & Selig, 2013; Lohr & Gall, 2007; Loncke, Campbell, England & Haley, 2006).

The first channel deals with verbal information in the form of logogens (Paivio, 1986; Ryu, Lai & Colaric, 2000) which encapsulate the linguistic component of the word-problems.

Thus when children are presented with verbally presented word-problems, the words are stored through the auditory channels as logogens.

The second channel has to do with imagens, which are the imagery and nonverbal objects and settings used in word-problems (Paivio, 1986; Ryu et al., 2000). Research has shown that children with intellectual disabilities, including those with autism and Down syndrome, benefit from visual support (e.g. Buckley, 2008; Drager, Postal, Carrolus, Castellano, Gagliano & Glynn, 2006; Foreman & Crews, 1998; Henry & MacLean, 2002; Oelwein, 1995). There is also consensus that organisation of the word-problem information and subsequent solution is enhanced through visual representation of the word-problem (Lucangeli, Tressoldi & Cendron, 1998). The presentation of the visual version of the verbal words enables children with intellectual disabilities to map the word to the pictorial version for clarification when they are unsure of the verbal word.

Applying the dual-coding theory during the solution phase of word-problem solving means that children listen to and process the oral word-problems (logogens) in auditory memory while simultaneously processing the visual representation (imagens) in visual memory (Mayer & Moreno, 1998). Paivio (1980) stipulates that while these two channels are independent, they are also interconnected due to their ability to initiate activity within the other channel once it has been triggered. Accordingly, the visual and auditory channels “assume complimentary functions” (Loncke et al., 2006, p.169). This means that the interconnected neural network is activated (Van Balkom & Verhoeven, 2010) which enables children to develop an understanding of the word-problems using both spoken and visual information. This argument contradicts the earlier “principle of graceful degradation” (Norman & Bobrow, 1975, p.45) which stipulates that when processes (imagens and logogens) compete for the same resources (attending), deterioration in performance will be observed. A limitation of the dual-coding theory is that referential connections cannot be effected if the corresponding verbal and visual information is not simultaneously present in working memory (Mayer & Moreno, 1998).

2.5.2 The effect of memory on word-problem solving

Children with intellectual disabilities need to remember word-problems for long enough to manipulate the linguistic and logico-mathematical information so as to comprehend and solve them. Inherent weak memory of word-problem information seems to complicate the solution process (Doyle, 1988; González & Espinel, 2002; Henry & MacLean, 2002). Research intimates that memory difficulties are exacerbated during mathematics due to the combined effect of language and the specific teaching methods employed (Bilsky & Judd, 1986; Goodstein, Cawley, Gordon & Helfgott, 1971; Henry & MacLean, 2002; Keeler & Swanson, 2001; Lifshitz, Shtein, Weiss & Svisrsky, 2005; Parmar et al., 1996; Rasmussen & Bisanz, 2005; Swanson & Sachse-Lee, 2001). As a result, should the required information not be readily accessible due to difficulties in understanding the terminology or the manner in which word-problem solving has been taught, children are left to either guess the answer or to give up. The aim for children with intellectual disabilities should, therefore, be to optimise retention so as to improve word-problem solving (Lowrie & Kay, 2001). Working memory involves the temporary storage and processing of incoming information that facilitates word-problem solving (Zheng et al., 2011). Components of working memory that seem to impact on word-problem solving have thus been researched (LeFevre, Fast, Smith-Chant, Skwarchuk & Bisanz, 2010).

From the available empirical evidence, two subsystems in particular appear to be affected when children solve word-problems (Bull, Johnston & Roy, 1999; Holmes, Adams

& Hamilton, 2008; LeFevre et al., 2010; Rasmussen & Bisanz, 2005; Swanson & Sachse-Lee, 2001; Zheng et al., 2011). These subsystems are the phonological loop and the visual spatial sketchpad, both of which are components of Baddeley's model of working memory, which is a widely accepted model for understanding word-problem solving (Andersson, 2007; Baddeley, 1986, 2000, 2003; Krajewski & Schneider, 2009; Swanson & Sachse-Lee, 2001).

Baddeley's (1992) original model comprised three sections. The central executive or attentional control system directs action planning and is responsible for controlling attention so that information such as word-problems can be encoded, retrieved and reasoned through. Central executive tasks are important in childhood, and for those who battle to perform these tasks difficulties are often noted in the learning areas of literacy and mathematics (Gathercole & Pickering, 2001). The central executive system also transfers information to the "two slave systems" (Baddeley, 1992; Henry & MacLean, 2008). The two slave or subsystems are the visuospatial sketchpad and the phonological loop. The visuospatial sketchpad is responsible for storing both visual and spatial information such as pictorial representations and manipulatives used to solve word-problems, and consequently stores what Paivio (1986) refers to as imagens. By storing imagens, children with intellectual disabilities may better recall word-problems since the cognitive load associated with the imagens is less (Lowrie & Kay, 2001). The phonological loop stores logogens, described by Paivio (1986) as sound-based information used for vocabulary acquisition. The words of word-problems are thus stored in the phonological loop and new words used in unfamiliar word-problems are internalised here (Baddeley, 1992; Henry & MacLean, 2008; Larrson & Dahl-Sandberg, 2008). The working memory model was later revised to also include the episodic buffer. This interacts with both the visuospatial sketchpad and the phonological loop to integrate information from the two slave systems for application, and in so doing assumes the role of a backup store (Baddeley, 2000; Baddeley, 2003; Henry, 2008; Lohr & Gall, 2007; Repovs & Baddeley, 2006).

2.5.3 A processing model for word-problem solving by children with intellectual disabilities

Mayer and Moreno (1998, 2000) and Mayer (2005) succinctly draw connections between Paivio's dual-coding theory (1980) and the working-memory model of Baddeley (1986). The new model that was developed by merging those of Paivio and Baddeley was aimed at exploring instruction for multimedia learning specifically (Mayer & Moreno, 1998, 2000). However, this model alludes to the viability of using the core features of Paivio and Baddeley's models in an integrated manner that could optimise word-problem solving for children with intellectual disabilities. Along these lines, it is contended that using the two independent verbal and nonverbal modes would enable children with intellectual disabilities to process and remember the word-problems more effectively.

The two elements of such a model incorporate a presentation mode which operationalises Paivio's model and a sensory mode which taps Baddeley's model. Accordingly, the presentation mode is concerned with the manner in which word-problems are presented. The verbal presentation has to do with spoken word-problems and the nonverbal presentation has to do with symbolic representation. In line with Paivio's dual-coding model, these channels of information are processed separately (Reed, 2006). The sensory mode involves the way in which the information is represented. According to Baddeley's working memory model, the visually presented information (symbols) and the auditorily presented information (spoken form of the word-problems) are distinguished within the phonological loop and visuospatial sketchpad. This model, adapted for word-problem solving by children with intellectual disabilities, is depicted in Figure 2.3.

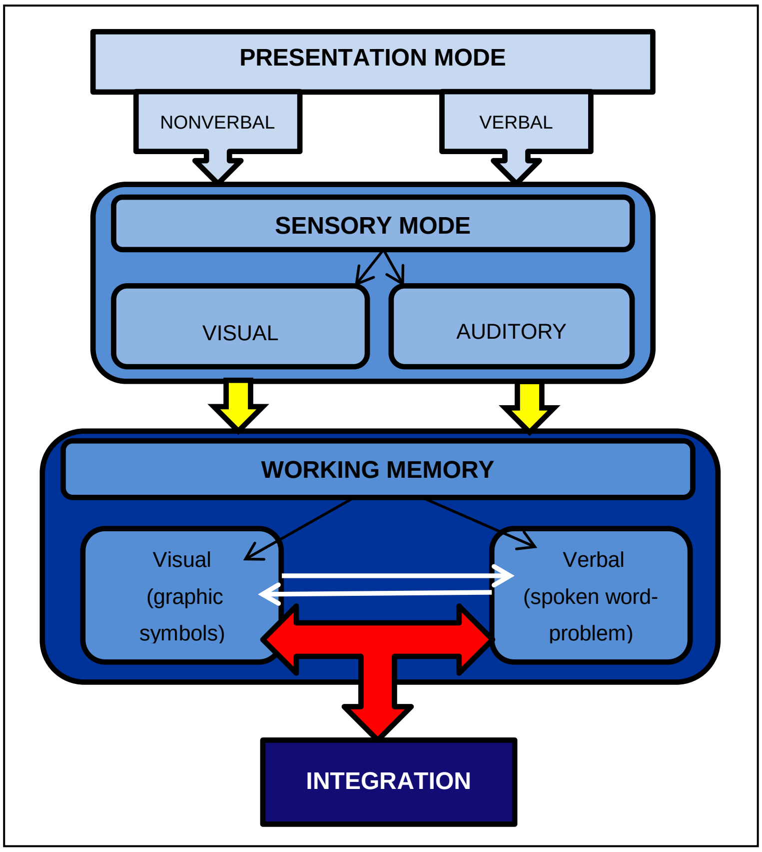

Figure 2.3 Multistore model (adapted from Moreno & Mayer, 2000)

Bearing the multistore model in mind in conjunction with the direct instruction strategies advocated for teaching children with intellectual disabilities, consideration of a suitable strategy that potentially operationalises this model and strategies is imperative. Such a strategy would need to employ spoken word-problems together with the visual representation (Swanson, Moran, Lussier & Fung, 2013). Accordingly, exploration of strategies in which visual representation is incorporated as a support for learning how to solve mathematical word-problems is needed. Consideration of augmented input strategies that fall within the field of AAC is consequently warranted.

2.6 AAC strategies to teach word-problem solving to children with intellectual disabilities

AAC refers to the field of practice aimed at improving the communication skills of individuals with little or no functional speech (Lloyd, 1997). Augmented input is a strategy to enhance the use of AAC systems by strengthening receptive language. Augmented input incorporates aided input, which can be defined as the "incoming communication or language from a communicative partner that includes speech that is supplemented by components of an AAC system" (Romski & Sevcik, 1988, p. 283). This definition clearly incorporates visual (aided) input to augment spoken input which is a practice within the field of AAC emphasized by Loncke et al (2006).

2.6.1 Visual support

For children with intellectual disabilities, the benefit of graphic symbols (aided support) to enhance receptive as well as expressive verbal language skills should not be understated (Stephenson & Linfoot, 1996). Much has been researched and written about the employment of visual aids to support and promote learning (Ahmad, Tarmizi & Nqwawi, 2010; Barton, Sevcik & Romski, 2006; Dettmer, Simpson, Smith Myles & Ganz, 2000; Higginbotham, Kim & Scally, 2007; McFadd & Wilkinson, 2010; McVay et al., 2003; Rao & Gagie, 2006). For example, at a preschool level where early intervention is essential, preschool children with developmental and language delays demonstrate "observational learning of visual graphic symbols" which has positive implications for the later use of visual aids to enhance learning through visual aids (Barton et al., 2006, p.19). Increased independence occurs since children use the aids on their own once they know how, and their understanding of information is also improved, which allows them to participate in class activities. Higginbotham et al. (2007) also seem to be proponents of visual aids, since their experiment revealed that the completion time and communication rate of participants were higher when visual aids in the form of visual letters were used during 10 direction-giving tasks. Despite their value in learning, graphic symbols need to be carefully selected to foster the desired outcomes (McFadd & Wilkinson, 2010). Hence, it would seem that graphic symbols can play an important role in developing receptive language in the AAC field.

Aided input using graphic symbols with speech in keeping with the Augmentative and Alternative Communication Input Framework (AACIF) (Wood et al., 1998) (see Section 4.2.1) has the potential for extensive employment for individuals experiencing communication challenges (Romski & Sevcik, 1988). The study conducted by Goossens' (1989), for example, confirms this as she found positive outcomes of aided input on the expressive skills of a six-year-old girl with cerebral palsy. The use of graphic symbols as employed by Goossens' (1989) to supplement spoken words appears to be a common AAC method. Aided symbols are often referred to as "graphic" since they tend to be permanent, stable and thus enduring, enabling the child to have access to them for as long as is needed (Lloyd & Fuller, 1986; Bornman & Rose, 2010). When completing word-problems, children are thus able to refer to the graphic symbols to facilitate recall of the taught word-problem. Graphic symbols can be displayed as part of a low-technology system such as paper and pencils, pictures, charts and communication boards, or as part of high-technology systems such as electronic devices. Graphic symbols that augment communication include Blissymbols, Cyberglyphs, Picture Communication Symbols (PCS symbols), Picsyms, Pictogram Ideogram Communication Rebus and Sigsymbols (Foreman & Crews, 1998; Lloyd & Fuller, 1986; Tönsing et al., 2005) with PCS symbols identified as being used most widely in South Africa (Bornman et al., 2011) as well as in the US (Tönsing et al., 2005).

2.6.2 AAC strategies to enhance the language of word-problems

Various augmented input strategies have been used in the AAC field. These include the System for Augmenting Language (SAL) (Romski & Sevcik, 1996), Aided Language Modelling (ALM) (Drager et al., 2006), Natural Aided Language (Cafiero, 1998) and Aided Language Stimulation (AiLgS) (Goossens', 1989, 1994, 2000).

The SAL which was developed by Romski and Sevcik (1996) requires the use of a voice output communication device during interactions with others. It is contended that the use of this device allows for spontaneous communication since the adult could, for example, attend to the child more specifically rather than focus on the AAC system being used (Romski & Sevcik, 1996). However, this strategy may not be viable for many teachers in a classroom setting, given that neither they nor the children may have access to these devices. Furthermore, the process described here already includes exposure to spoken input accompanied by visual input, making the use of a device unnecessary for use by the teacher. Symbols are introduced gradually using the SAL (Romski & Sevcik, 1996). This practice may, however, be problematic in a school setting where the gradual introduction of graphic symbols may hamper concept acquisition due to lack of symbol awareness.

ALM, discussed by Drager et al. (2006), incorporates the common features of other augmented strategies, namely augmenting a message and providing a model. It is thus not regarded as conforming to one specific technique (Drager et al., 2006). The process of ALM involves three elements. The first involves pointing to an environmental referent and the second entails a graphic symbol that represents the referent being pointed to. In the third element the graphic symbol is verbalised at the same time as the symbol is pointed to. While ALM incorporates augmented strategies, the frequency of augmented input required is limited to four times for each item as it is used during intervention (Drager et al., 2006). This is likely to be challenging when teaching subtraction word-problem solving since the words used to elaborate on the word-problem vocabulary occur more than four times.

Natural Aided Language (Cafiero, 1998) was developed specifically for children with autism and appears to be successful in increasing receptive and expressive vocabulary while simultaneously improving behaviour (Cafiero, 2001). It requires specific vocabulary using graphic symbols (PCS symbols) to be chosen and reinforced for a specific activity (Drager et al., 2006). The facilitator then assumes a model role while using the symbols. Boards are made available to children to facilitate incidental teaching opportunities. The natural aided language approach does not stipulate the frequency of the natural aided language (Dada & Alant, 2009). This may make it difficult to ascertain the appropriate frequency of natural aided language that would maximize subtraction word-problem solving for children with intellectual disabilities. Furthermore, it is necessary to have multiple boards on hand to facilitate incidental interactional opportunities (Drager et al., 2006). However, given that direct instruction is advocated for the teaching of subtraction word-problems; the use of the boards used for incidental interactional opportunities would not be possible.

AiLgS is essentially a variation of a “verbal language stimulation approach” to replicate natural speech patterns that facilitate comprehension of the language (Goossens’, 1989, p.16). In this way, children are shown through modelling by the facilitator how to use an interactive aided communication system (Dada, 2004). AiLgS is thus a strategy that involves a facilitator pointing with an index finger, torch or pointer to specific graphic symbols that are arranged on a communication display such as a facilitator board, vest or eye-gaze frame while simultaneously conducting continued verbal language stimulation (Dada &

Alant, 2009; Goossens', 1989). Goossens' (2000) recommends that the facilitator follow a ratio of 80:20 for statements: questions used and that at least 80% of the symbols on the communication display are used during an interaction. One word-problem presented to participants, for example, is *Zinzi has 7 sweets. Then she gives some to Joe. Now Zinzi has 2 sweets. How many sweets does Zinzi give to Joe?* The facilitator then points to the PCS symbols for *ZINZI*, *HAS*, *7*, *SWEETS*, *GIVES*, *SOME*, *JOE*, *ZINZI*, *HAS*, *2 SWEETS*, *HOW-MANY SWEETS*, *ZINZI*, *GIVE* and *JOE* with a pointer while simultaneously verbalizing each of the words.

Research using AiLgS has shown that it can be used successfully to improve language skills. In the study conducted by Harris and Reichle (2004), the effect of using AiLgS to help three preschool children who were functionally nonspeaking with moderate intellectual disabilities to increase their comprehension and production of graphic symbols was explored. During the intervention phase, the experimenters used a script developed for a preferred activity and the 12 symbols and/or 12 objects selected were pointed to four times during each session. Probes were conducted to measure comprehension and production of graphic symbols and spoken words, comprehension of exclusively graphic symbols and comprehension of exclusively spoken symbols. The results revealed that AiLgS was effective in facilitating and maintaining symbol comprehension for all three preschoolers. It was also effective in facilitating and maintaining symbol production in which objects were labelled.

Bruno and Trembath (2006) determined that a week-long training programme using AiLgS improved the syntactic performance of nine children aged between 4;0 and 15;0. For the programme children used their own dynamic display speech generating device (DD-SGD) and the manual communication boards that were available. During two daily intervention sessions over five days, children used their DD-SGD in an arts and crafts activity and the manual communication board in the “magnetic town” activity. In each activity therapists provided AiLgS throughout the two activities and tried to model messages for individual children that were slightly more complex than the mean modelled message length identified during the pretest measures. The post-test completed after the five-day training programme revealed that the complexity of the children’s spontaneous and modelled messages improved, with the greatest improvement being observed when children used the manual communication boards.

The effect of an AiLgS programme on the receptive vocabulary of children with little or no functional speech was researched by Dada and Alant (2009). For this study four children aged between 8.1 and 12.1 were selected as participants by their teacher and speech and language therapist. They were identified as having little or no functional speech which describes a vocabulary of less than 15 intelligible words (Burd, Hammes, Bornhoeft & Fisher, 1988) but were all able to identify some line drawings. In the intervention, the researcher exposed the children to three activities (making a sheep in arts and crafts, making pudding in food preparation and listening to the story of Goldilocks and the three bears in story time) in a small group. A facilitator board was developed for each activity and used during the training procedure, which involved exposing the children to the target vocabulary items three times using AiLgS. Results from the study indicate that each of the children demonstrated improvement in their receptive language skills following exposure to the three activities using AiLgS.

Parents’ use and experience of ComAlong communication boards with their children (who experienced communication difficulties) through AiLgS was researched by Jonsson, Kristoffersson, Ferm and Thunberg (2011). In the ComAlong course parents were trained to model AAC for their children, using aided communication devices in the form of ComAlong boards through AiLgS, which was referred to as “point-talk” in the training (Jonsson et al., 2011, p. 104). Jonsson et al.’s study (2011) included 43 mothers and 22 fathers who attended the ComAlong course. These parents completed anonymous questionnaires and four of the parents also participated in a case study. Questionnaires, interviews, logbooks and video recordings were used to collect and analyse the data related to how parents used and experienced the ComAlong boards while interacting with their children at home. Results from the study indicated that 40% of the parents had either not started using the boards or saw no difference in communication when using them. The other 60% of the parents experienced positive changes in communication with their children. Analysis of the video recordings revealed that the parents did in fact use the ComAlong board displays while talking to their children, reflecting AiLgS principles.

While various AAC strategies as described above have merits as to their potential application for children with intellectual disabilities, careful consideration is needed regarding the strategy that may optimise the teaching of mathematical word-problem solving. Furthermore, the strategy should align well with the direct instruction proven to be successful for teaching children with intellectual disabilities. Accordingly, AiLgS (Goossens’, 1989) seems to meet the requirements for teaching mathematical word-problem solving to children with intellectual disabilities most effectively. AiLgS principles stipulate the frequency of aided language stimulation to be done as well as the nature thereof, which would enable consistent employment of this strategy for all children with intellectual disabilities.

2.7 Conclusion

This chapter explored the factors that impact on word-problem solving for children with intellectual disabilities. The discussion began by considering the importance of mathematics for children with intellectual disabilities in contributing to the development of daily living skills. Next, word-problem solving in terms of its development was presented. Two models of word-problem solving representation were reviewed together with two developmental views of word-problem solving. Thereafter pedagogical considerations of teaching word-problem solving related to educational trends and teaching strategies were presented. Subsequent to this, multimodal models that may potentially be used for word-problem solving were discussed. The chapter ended with a discussion about augmented input, which falls within the field of AAC given its potential application to teaching word-problem solving to children with intellectual disabilities where a multimodal model is operationalised.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the research methodology that was used in the study. The description begins by stating the main and subaims of the study and is followed by a description of the research design and phases. Thereafter, the pilot studies in terms of the objectives and methods, which include procedures and measures as well as results and recommendations, are presented. A description of the participants, data collection methods and data analysis procedures that were employed during the main study is then provided. Finally, reliability of the data in this study is presented.

3.2 Methodology

3.2.1Main aim

The main aim of this study is to describe the effect of a mathematical aided language stimulation (MAiLgS) programme on the subtraction word-problem solving skills for children with intellectual disabilities aged between 8;0 and 12;0.

3.2.2 Sub aims

Seven sub aims delineate the main aim, namely:

(i) To develop an MAiLgS programme to facilitate word-problem solving for three types of subtraction word-problems

(ii) To obtain baseline data of accurate independent answers to three types of subtraction word-problems *prior to* the implementation of the MAiLgS programme

(iii) To implement the MAiLgS programme

(iv) To measure three types of subtraction word-problems *during exposure to* the MAiLgS programme

(v) To conduct maintenance probes to determine subtraction word-problem solving skills for the three types of subtraction word-problems three weeks *after exposure* to the MAiLgS programme

(vi) To describe the reliability of the procedures and data used in the study

(vii) To determine whether the MAiLgS programme improves the subtraction word-problem solving skills of children with intellectual disabilities

3.3 Research design

A single-subject, multiple baseline design across behaviours with maintenance, replicated across participants was used (Gast & Ledford, 2010; Horner & Baer, 1978; Murphy & Bryan, 2001). The maintenance probes were conducted four weeks after intervention ended. This design is believed to be valuable in the study of children with intellectual disabilities in a learning setting since all targeted behaviours (three types of word-problem) could be assessed continuously. This allows the researcher to obtain a complete representation of each participant's performance across the three types of word-problem (Schlosser, 2003). It also enables the researcher to control for internal validity and demonstrate experimental control (Gast & Ledford, 2010). Furthermore, it does not require the word-problem solving ability of participants to be reversed to demonstrate a causal effect of the intervention (Murphy & Bryan, 2001).

The multiple baseline design across behaviours (word-problem types) and replicated across participants requires baseline data for each word-problem type to be collected continuously for a minimum of three consecutive days prior to the introduction of the intervention. Once a stable initial baseline for all three word-problem types was obtained, the intervention was initiated in a small-group setting with the first word-problem type (change) while the remaining two, combine and compare (Riley et al., 1983) remained in baseline. Probes were conducted for the change type word-problems using the small-group format on each of the five days after each intervention session to determine whether performance within the change word-problem type was being maintained by individual participants (Gast & Ledford, 2010). When intervention on the change type word-problems ceased, intervention on the combine type word-problems commenced and the procedure outlined for the change type word-problems was replicated and then repeated with the compare type word-problems. After a withdrawal period of four weeks (Gast & Ledford, 2010), three maintenance probes were conducted for all three word-problem types in order to determine whether participants had maintained the subtraction word-problem solving skills after withdrawal of intervention.

The independent variable (IV) in this study was the use of an MAiLgS programme while the dependent variable (DV) was the number of accurate answers for subtraction word-problems during the probe measures. The teaching criterion describes the “predetermined maximum number of teaching sessions” which guided termination of the intervention (Schlosser, 1999, p. 63). For this study the teaching criterion was five sessions, in keeping with the academic week. Learning criteria were not used for this study since including them may have extended the study duration beyond the time limit granted by the school which was informed by the school terms dictated by the Gauteng Department of Education (GDE, 2014).

3.3.1 Phases of the research

This study comprised two phases namely a pre-experimental phase and an experimental phase as illustrated in Table 3.1. The pre-experimental phase involved i) obtaining ethical approval from the University of Pretoria (Appendix A). Consent was obtained from the school principal (Appendix B) and teachers (Appendix C) of an independent school that accommodates children with special educational needs, and also from the parents of potential participants (Appendix D). Assent was obtained from all of the potential participants (Appendix E); ii) the development of the MAiLgS programme; iii) selecting the PCS symbols used in the intervention; iv) development of the probe measures and v) conducting the pilot studies.

The experimental phase of the study consisted of: i) participant identification; ii) pre-intervention assessment; iii) baseline probes; iv) implementation of the intervention programme; v) obtaining intervention probe measures and vi) obtaining maintenance probe measures.

3.4 Pre-experimental phase: pilot studies

3.4.1. Pilot Study 1

The aim of the first pilot study was to test the methods and procedures to be used in the main study (Thabane et al., 2010). The pilot study thus examined the participation selection criteria, procedures and appropriateness of the MAiLgS. The procedures outlined for the main study in Section 3.5 were used in the pilot study and it was conducted at a school similar to the one used in the main study. Eight participants met the selection criteria of the study (see Table 3.4) and were included in the pilot study (Appendix U).

Table 3.1 Research phases

Phase 1: Pre-Experimental Phase				
Phase 1.1	**Phase 1.2**	**Phase 1.3**	**Phase 1.4**	**Phase 1.5**
Obtain ethical approval, consent and assent.	Develop the MAiLgS programme scripts.	Select PCS symbols to be used for the MAiLgS programme.	Develop probe measures.	Conduct two pilot studies.
The proposed study was submitted to the ethics committee of the University of Pretoria for approval (Appendix A). On approval, ethical approval was granted. Consent was obtained from identified sites including the principal (Appendix B), teachers (Appendix C) and parents of potential participants (Appendix D). Potential participants provided assent to participate (Appendix E).	The guiding principles of the AiLgS (Goossens', 1989) dictated the process of the intervention programme. It comprised three word-problem types as per Riley et al.'s (1983) model of word-problems for subtraction (change, combine and compare) (Appendices K, L & M). See Sections 3.9.1.4 and 4.2 for further detail.	Possible PCS symbols were presented to 15 typically developing Grade R children (Appendix G). They selected the PCS symbols they believed best represented the vocabulary to be used in the MAiLgS programme (Appendix H). The PCS symbols chosen most often were used to represent the symbols in the MAiLgS programme. See Section 4.4.1 for further details.	Probe tests were used to measure each participant's ability to solve subtraction change, combine and compare word-problems. The probe test scripts were used to read the questions to participants in the same way during each probe test (Appendices N. O & P). Participants recorded their solutions on the probe answer sheets developed for each word-problem type (Appendices Q, R & S). See Section 3.7.2.9 for more information.	The two pilot studies were intended to test the feasibility of the methods, to evaluate the MAiLgS programme and to make the necessary modifications prior to the main study. See Tables 3.2 and 3.3 for the objectives, procedures, results and recommendations of the pilot studies.

Table 3.1 Research phases continued

Phase 2: Experimental Phase					
Phase 2.1	**Phase 2.2**	**Phase 2.3**	**Phase 2.4**	**Phase 2.5**	**Phase 2.6**
Identify potential participants.	Conduct pre-intervention assessment of potential participants.	Obtain baseline measures.	Implement intervention.	Obtain intervention probe measures.	Obtain maintenance probe measures.
Prospective participants were screened using the Learner Screening Tool by Teachers (LeSTE) (Appendix F).	Prospective participants were screened using: Standardised tests: 1) Kaufman Brief Intelligence test – Second Edition (KBIT-2) (Kaufman & Kaufman, 2004). 2) Wechsler Individual Achievement Test-II Numerical Operations and Mathematical Reasoning Scales (Wechsler, 2005). 3) Peabody Picture Vocabulary Test-IV (Dunn & Dunn, 2007). See Table 3.3 for more information. Non-standardised tests: 1) Informal Counting test (Appendix J) (Section 3.7.2.5) 2) PCS symbol Identification Test (Appendix I) (Section 3.7.2.6)	Baseline measures were done with participants in the small group on the first day of the study. The baseline needed to be stable before participants were introduced to the group intervention, as per the guidelines of Horner et al. (1976). Participants recorded their answers on the baseline probe answer sheet (Appendix Q). Their scores were recorded in the individual participant graphs (See Section 5.6). See Section 3.8.4 for further information.	The MAiLgS programme was introduced to participants in a small group. The intervention involved exposing the group to each word-problem type over 5 consecutive days. One session per day was completed. See Section 3.8.5 for more detail. During intervention participants circled answers to the taught word-problems on the intervention answer sheets (Appendix T).	Intervention probe measures were conducted within the small-group format used every day. The probe measures followed the intervention phase and a short break of five minutes. The format of the initial baseline measure was used. Participants indicated their answers on the intervention probe answer sheets by circling the correct answer (Appendix R). See Section 3.8.4 for further elaboration.	A maintenance probe was conducted four weeks after the final intervention probe measures were conducted. The probe measure format used during the initial baseline and intervention probe measures was used. Participants indicated their answers on the maintenance probe answer sheets by circling the correct answer (Appendix S). See Section 3.8.4 for further discussion.

The ages of participants ranged from 8;1 to 11;0. There were two female and six male participants, who were enrolled at a school for children with special needs. Their IQ scores ranged from below 60 to 80. Three participants were diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) and one with Epilepsy; one had a heart condition, one presented with a speech impediment, one had a generalised developmental delay and one had developed learning difficulties following a traumatic experience. All participants were ambulatory and able to speak.

3.4.2 Objectives, procedures, results and recommendations of Pilot Study 1

Table 3.2 delineates the objectives, procedures, results and recommendations of this pilot study. The pilot study resulted in a revision of the participant selection criteria. The standardised tests were also revised as outlined in Table 3.2. Further revisions and modifications relating to the MAiLgS programme materials were made as follows: i) the number of taught word-problems were increased from three to six; ii) only taught word-problems were measured; iii) the time required to do the intervention was extended to 40 minutes.

Table 3.2 Objectives, procedures, results and recommendations following Pilot Study 1

Objectives	Procedures	Results	Recommendations for main study
1. To evaluate the appropriateness of the measures to select participants:			
a) The LeSTE (Appendix F) • Chronological age • Functional vision • Functional hearing • Functional motor skills • English as the LoLT for at least two years	The teachers who have worked with children for at least six months completed the LeSTE.	Teachers found the LeSTE easy to understand and straightforward to complete.	The LeSTE should be used in its current format with attention and concentration being incorporated under Cognitive Functioning as suggested in Objective 1c.
b)The Raven's Coloured Progressive Matrices and Crichton Vocabulary Scales (2008) to measure a moderate intellectual disability (IQ score between 40 and 70).	The test was administered with individual children by the researcher, an educational psychologist registered with the HPCSA.	IQ scores below 60 could not be quantified by this measure.	Replace the Raven's Coloured Progressive Matrices and Crichton Vocabulary Scales (2008) with the Kaufman Brief Intelligence Test – Second Edition (Kaufman & Kaufman, 2004) (KBIT-2), which quantifies IQ scores for the age group 8.00 to 12.00 from 40.
c) The Copeland Symptom Checklist for Children to measure attention and concentration for 20 minutes.	Teachers completed the checklist for each child.	Teachers reported that this checklist was time-consuming to complete and suggested that items describing attention and concentration should be included in the LeSTE instead.	Include items that explore attention and concentration in the LeSTE and ask the teachers to re-evaluate it prior to use in the main study.
d) The Peabody Picture Vocabulary Test – 4 (PPVT-4) (Dunn & Dunn, 2007). Receptive vocabulary to score between 5;0 and 7;11.	The test was administered with individual children by the researcher.	The PPVT-4 was effective in determine the receptive vocabulary of children.	The PPVT-4 should be used to measure receptive vocabulary.
e) The Oral and Written Language Scales – Second Edition (OWLS-II) oral expression scale. Expressive vocabulary to score between 5;0 and 7;11.	The test was administered with individual children by the researcher.	The OWLS-II was effective in measuring the expressive vocabulary of the children.	Since the focus of AiLgS is receptive language skill development (Goossens', 2000) and responses for probes in the programme are written, expressive vocabulary should not be a selection criterion.

Table 3.2 Objectives, procedures, results and recommendations following Pilot Study 1 cont.

Objectives	Procedures	Results	Recommendations for main study
f) The Wechsler Individual Achievement Test – Second Edition (WIAT-II) (Wechsler, 2005): Numerical Operations and Mathematical Reasoning subtests. Mathematical skills must score between 5;0 and 7;11.	The test was administered with individual children by the researcher.	The WIAT-II was effective in measuring mathematical skills of children.	The WIAT-II Numerical Operations and Mathematical Reasoning subtests should be used. A further informal test to determine each child's ability to count out a given number of counters should be included.
g) PCS symbols Identification Test (Appendix I) to measure children's ability to identify PCS symbols during the first day.	Participants were asked to point to the appropriate symbol that corresponded with the spoken word.	The PCS symbols Identification Test was effective in measuring the children's ability to identify PCS symbols.	Four days should be used to test children instead of one. A paired teaching strategy should also be used to teach the symbols not identified by children during the first three days. Identification of PCS symbols should be 90% accurate on the fourth day.
2. To ensure that the venue is suitable for small group intervention.	The video recordings of the intervention and probe sessions were watched to ensure that there was sufficient light in the venue and that it was not situated near any noisy activities. Participants' responses to teaching materials within the venue were also noted.	Certain external distractions could not be controlled for (e.g. children entering the classrooms to collect something). It was not possible to remove the posters from the walls but they did not appear to distract participants.	The venue should be familiar to the participants, as they are less likely to be anxious than in a new venue or distracted by the contents of the venue.
3. To determine the video and audio clarity of video recordings.	The video recordings were watched to ensure that the facilitator board, researcher and participants were visible. They were also watched to ensure that the verbal interaction was audible and that the facilitator's demonstrations were visible.	The actions of participants were not always visible while those of the researcher were. The audio recording was audible and clear.	The camera recording participants should be placed at the front of the classroom. The camera recording the facilitator should remain positioned behind participants.

Table 3.2 Objectives, procedures, results and recommendations following Pilot Study 1 cont.

Objectives	Procedures	Results	Recommendations for main study
4. To evaluate the probe sessions in terms of:			
a) Probe materials	Participants used the manipulatives and calculation mats to calculate the word-problems and circle the answers on the probe answer sheets.	The separate calculation mats and PCS symbols proved to be cumbersome while the manipulatives were easily handled. Participants understood how to circle their answers but some required numbers not present on the answer sheet.	An A3 version of the facilitator board is recommended instead of separate calculation mats and PCS symbols. A blank column at the end of the row of numbers should be added to allow participants to write in a number that is not present on the answer sheet.
b) The probe script (Appendices N, O & P)	The researcher read the word-problems from the probe scripts. Probe items included the three taught word-problems as well as 3 untaught word-problems for each type of word-problem.	Word-problems were used in the script format but repeated at the request of participants.	The probe script should be used in the current format with a maximum of 3 repetitions of the entire word-problem being given. Measure only the taught word-problems. Untaught word-problems should not be probed.
c) Time allocation	Thirty minutes were allocated to complete the probe sessions as this is the duration of a typical activity at school.	Thirty minutes proved to be too little time due to the number of repetitions of word-problems done.	30-minute sessions should be used to prevent participant fatigue. There should be less repetition of word-problems (see point 4b) to reduce duration of the probe sessions.
d) Small group administration	A small group of eight participants was used.	The small group was easily managed.	Use the small group format.
5. To evaluate the intervention sessions in terms of:			
a) Facilitator board	The facilitator board was used to teach the intervention word-problems. It had to be easily visible to each participant and allow easy access to the PCS symbols by the researcher.	The PCS symbols were visible to participants but the red and purple calculation mats were too small for effective calculation demonstration. The symbols for *PRAVIN*, *SUE*, *MARBLES* and *TRY* are no longer needed (as per 5b).	The red and purple calculation mats should be made bigger. Replace superfluous symbols with *MOVE*, *SHARE*, *KEEP* and *DON'T KNOW*.

Table 3.2 Objectives, procedures, results and recommendations following Pilot Study 1 cont.

Objectives	Procedures	Results	Recommendations for main study
b) Appropriateness of the MAiLgS programme	The format of the 3 taught word-problems and explanation thereof were explored using the intervention scripts and video recordings. Participant answers to probe test word-problems were also used to determine the appropriateness of the programme.	Participants were able to complete the change word-problems prior to being taught, suggesting that the current format was too easy. They were unable to solve the compare word-problems even after being taught.	Make the change word-problems more difficult and re-examine the teaching method for the compare word-problems. Use 6 teaching word-problems instead of 3 to increase exposure to the teaching of each word-problem type.
c) Intervention materials	Manipulatives were used to demonstrate word-problem calculations on the red and purple calculation mats on the facilitator board. Participants circled the answers to the taught word-problems on their intervention answer sheets.	The manipulatives were easy to handle. Participants understood how to circle the word-problem answers on the intervention answer sheets.	The manipulatives and intervention sheet should be used in their current format.
d) Time allocation	The video recordings were watched to determine whether participants were engaged for the 20-minute sessions as per Section 3.6.3.	20 minutes proved to be sufficient time to teach 3 word-problems.	Since a recommendation is to teach 6 word-problems as per 5b, the time allocation for teaching should be increased to 40 minutes.
e) Teaching criterion of 5 days	The first two behaviours were taught for 5 consecutive days. The third behaviour was taught for 4 consecutive days due to the fifth day being a public holiday.	Participants demonstrated increased scores shortly after intervention suggesting that the teaching criterion is suitable.	The 5-day teaching criterion should be used.
f) Small group intervention for 8 participants	The small group format was used.	The small group was easily managed.	Use the small group format.

Table 3.2 Objectives, procedures, results and recommendations following Pilot Study 1 cont.

Objectives	Procedures	Results	Recommendations for main study
6. To determine the accuracy of the data collection: a) Scoring of probe answer sheets (Appendices Q, R & S).	Participant probe answer sheets for all probe sessions were scored by the researcher. The inter-rater then scored 100% of the probe sessions in the baseline, intervention and maintenance phases.	Comparison of the scoring of the probe answer sheets revealed 100% agreement between the researcher and inter-rater.	The probe answer sheet scoring should be done in the same way.
7. To determine the accuracy of procedural integrity checklists (Appendices W & X).	The procedural integrity checklists were completed by the researcher for all intervention and probe sessions. The inter-rater calculated procedural integrity for 40% of the randomly selected transcriptions.	Comparison of the researcher and inter-rater’s checklists revealed 95.1% agreement relating to intervention sessions and 93.8% for the probe sessions.	The procedural integrity checklists should be used in the current format for the main study.
8. To determine whether the frequency of AiLgS was used 80% of the time in keeping with AiLgS principles.	The researcher analysed each intervention transcription and the inter-rater analysed 40% of the randomly selected transcriptions.	Frequency of AiLgS was used 80% of the time according to the researcher and inter-rater checklists.	The transcriptions should be used to determine whether the frequency of AiLgS was 80% in each of the sessions.
9. To determine whether the 80:20 statement: question ratio was used in keeping with AiLgS principles.	The researcher analysed each intervention transcription and the inter-rater analysed 40% of the randomly selected transcriptions.	Aided language stimulation was used in the ratio of 80:20 according to the research and inter-rater checklists.	The transcriptions should be used to determine whether the required 80:20 ration for AiLgS was done.

From Table 3.2 it is clear that while the MAiLgS programme appeared to enhance subtraction word-problems, certain modifications were necessary in order for its execution to be optimised. A second pilot study was therefore completed to ensure that the modifications made were appropriate.

3.4.3 Pilot Study 2

The aim of the second pilot study was to evaluate the revised participation selection criteria, procedures and materials prior to using them in the main study. The revised participant selection criteria for the study were included and the data collection procedures were the same as those outlined for the main study. Table 3.3 delineates the objectives, equipment and materials, measures, procedures, results and recommendations that were explored during the second pilot study.

Two participants who met the revised selection were included in the pilot study (Appendix V). The ages of the participants were 9;0 and 9;0. One was female and the other was male. The participants were enrolled at a school for children with special needs. One participant was diagnosed with ADHD and the other had a generalised developmental delay. Both participants were ambulatory and able to speak.

Table 3.3 Objectives, procedures, results and recommendations following Pilot Study 2

Objectives	Procedures	Results	Recommendations for main study
1. To evaluate the appropriateness of the measures used to select participants for inclusion in the study:			
a) Kaufman Brief Intelligence Test – Second Edition (Kaufman & Kaufman, 2004) (KBIT-2) to measure a moderate intellectual disability (IQ score between 40 & 70).	The test was administered with individual children by the researcher, an educational psychologist registered with the HPCSA.	The KBIT-2 was effective in measuring IQ scores above 40 for children aged 8.00 to 12.00.	The KBIT-2 should be used to measure an intellectual disability. Given the scores of potential participants, the required IQ score range should be changed to between 40 and 69, equating with the Extremely Low Range described by Kaufman (2004), rather than being described as a moderate intellectual disability specified in the DSM-5.
b) The Peabody Picture Vocabulary Test – 4 (PPVT-4) (Dunn & Dunn, 2007). Receptive vocabulary to score between 5;0 & 7;11.	The test was administered with individual children by the researcher.	The PPVT-4 was effective in determining the receptive vocabulary of the children.	The PPVT-4 should be used to measure receptive vocabulary. Given the scores of potential participants, the required age range should be changed to score between 4.00 and 8.00.
c) The Wechsler Individual Achievement Test – Second Edition (WIAT-II) (Wechsler, 2005): Numerical Operations and Mathematical Reasoning subtests. Mathematical skills to score between 5;0 & 7;11.	The test was administered with individual children by the researcher.	The WIAT-II was effective in measuring the mathematical skills of the children.	The WIAT-II Numerical Operations and Mathematical Reasoning subtests should be used. Given the scores of potential participants, the required age range should be changed to score between 4.00 and 8.00.
d) PCS symbols Identification Test (Appendix I) to measure children's ability to identify 90% of PCS symbols on the fourth day.	Participants were asked to point to the appropriate symbol that corresponded with the spoken word.	The PCS symbols Identification Test was effective in measuring the children's ability to identify PCS symbols.	The PCS symbols Identification Test should be used in its current format.
4. To evaluate the probe sessions in terms of:			
a) Time allocation	30 minutes were allocated to complete the probe sessions.	30 minutes proved to be sufficient.	30-minute sessions should be provided in the main study

Table 3.3 Objectives, procedures, results and recommendations following Pilot Study 2 cont.

Objectives	Procedures	Results	Recommendations for main study
5. To evaluate the intervention sessions in terms of:			
a) Facilitator board	The PCS symbols had to be easily visible to each participant and the calculation mats had to be suitably sized for effective calculation demonstration. The PCS symbols included had to best represent the word-problem explanations.	The PCS symbols were visible to participants and the calculation mats were suitably sized for effective calculation demonstration. Five PCS symbols (*SHE*, *HE*, *YOU*, *EVERYBODY* and *AGAIN*) proved to be superfluous to solving the word-problems.	The facilitator board should be used in its current format. The superfluous PCS symbols should be substituted with the following: *AWAY*, *KNOW*, *WANT*, *ALL* and *FINISHED*.
b) Appropriateness of the MAiLgS programme	The format of the 6 taught word-problems and explanation thereof were explored using the intervention scripts and video recordings. Participant answers to probe word-problems were also used to determine the appropriateness of the MAiLgS programme.	Participants were able to complete word-problems after being taught.	The current format of the MAiLgS programme should be used.
c) Time allocation	The video recordings were watched to determine whether participants were engaged for the 40-minute sessions as per Section 3.6.3.	40 minutes proved to be sufficient time to teach the 6 word-problems.	40 minutes should be used to teach the intervention word-problems.

From Table 3.3 it is clear that the modifications made during Pilot Study 2 were effective and could be used for the main study.

3.5 Experimental phase: main study

The recommendations of Pilot Study 2 were implemented and the experimental phase of the study was conducted thereafter.

3.6 Participants

3.6.1 Description of the school

The school was purposively selected (Babbie & Mouton, 2001) for the main study as it accommodates children with intellectual disabilities and special educational needs. It is situated in an urban area located in Gauteng. The school is an independent school that has been operational since January 2009. There are 80 children enrolled at the school, which serves children with Attention Deficit-Hyperactivity Disorder, Autism, Brain Injury, Carnosinemia, Cerebral Palsy, Down syndrome, Epilepsy, General Developmental Delays, Hydrocephalus, Neurofibromatosis, Oppositional Defiant Disorder and Partial Trisomy 8. Children are exposed to English as the Language of Learning and Teaching (LoLT) and although most use English as their first language at home, others use Afrikaans, isiZulu, isiXhosa, Xitsonga, SiSwati and Sesotho as their first languages. There are eight children who are classified as having little or no functional speech.

There are five senior teachers who are responsible for each of the five classes. The teachers' qualifications vary from Bachelor's degrees in 'Psychology and Sociology' and 'Health Sciences and Social Services' to teaching diplomas and certificates in teaching. There are also eight facilitators and one learner assistant who are employed at the school to support the children in class. The services of an educational psychologist, an occupational therapist trained in neurodevelopment and a speech therapist are available at the school. Therapeutic interventions for the children include horse-riding, swimming, occupational therapy, art lessons, dancing, cricket, soccer and Active Kidz (which provides gross motor, fine motor and perceptual development training). The school day commences at 07:45 and ends at 13:30, when some children leave school and others stay at school in the aftercare centre, leaving before it closes at 18:00. The school is open throughout the year, closing only over the December school holidays in keeping with the Gauteng Department of Education's ruling. The school has five classrooms which are used for teaching throughout the day and a therapy room used for individual activities. There is a playground with climbing apparatus, two trampolines, two sand pits, a covered play area for children who are not mobile and a swimming pool on the premises.

3.6.2 Participant selection criteria

The participants were purposively selected according to the participant selection criteria delineated in Table 3.4 from the school described in Section 3.6.1 (Babbie & Mouton, 2001) as they needed to be representative of the general population of interest, namely children with intellectual disabilities. After consent was given by the principal to conduct the study at the school, 34 consent letters were sent home to parents to inform them of the research study and to inquire whether they would agree to their children being considered as potential participants. The other 46 children were not given consent letters, since the study would not impact on them in any way because they children were too young or were in the classes that catered for the children with severe intellectual disabilities who would not qualify as potential participants. Twenty consent letters were returned and each parent gave consent

Table 3.4 Participant selection criteria

Criteria	Measure	Justification
Chronological age between 8;0 and 12;0	Learner Screening Tool by Educators (Appendix F)	The selected tasks had to be meaningful and applicable to the selected age group.
Intellectual Disability with an IQ score between 40 and 69	Kaufman Brief Intelligence Test Second Edition (KBIT-2) (Kaufman & Kaufman, 2004)	Participants are functioning below the expected level for their chronological age to the extent that they experience difficulties in the classroom.
Attention and concentration span for up to 20 minutes	Learner Screening Tool by Educators (Appendix F)	Participants need to be able to attend during 3 tasks and concentrate on them for up to 20 minutes.
Functional vision	Learner Screening Tool by Educators (Appendix F)	Participants must be able to see the PCS symbols clearly.
Functional hearing	Learner Screening Tool by Educators (Appendix F)	Participants must be able to hear the explanation of the word-problems clearly.
Functional motor skills	Learner Screening Tool by Educators (Appendix F)	Participants must be able to manipulate the concrete apparatus used during the intervention and probes.
English as the LoLT for at least two years	Learner Screening Tool by Educators (Appendix F)	As tasks are conducted in English, participants must understand the language used.
Identification of 90% of the presented PCS symbols in response to the spoken label after four days	PCS symbols Identification Test (Appendix I)	Participants must be familiar with 90% of the PCS symbols for them to understand the PCS symbols used in the intervention programme. PCS symbols were revised with participants each day to increase their familiarity with the modified PCS symbols.
Receptive language skills between 4;0 and 8;0s	Peabody Picture Vocabulary Test-4 (PPVT-4)	Participants have to command a functional understanding of the words used during the intervention programme. The age range reflects Inhelder’s work, where children with moderate intellectual disabilities function between Piaget’s pre-operational and concrete operational stages of development (Du Toit, 1991).
Command of basic mathematical knowledge between 4;0 and 8;0	Wechsler Individual Achievement Test – Second Edition (Wechsler, 2005): Numerical operations and Mathematical reasoning subtests	Participants have to demonstrate the ability to calculate basic algorithms so as to do so accurately when solving the word-problems. Participants also need to demonstrate the ability to reason through word-problems so as to be able to solve them. As noted above, the selected age range is based on the work of Inhelder (Du Toit, 1991).
100% accuracy in the informal counting of manipulatives (counters)	Informal Counting Test (Appendix J)	Participants need to be able to count out a given number of manipulatives to facilitate correct calculations of word-problems.

for his/her child to be considered for the study. The other 14 consent letters were not returned. On receipt of the parental consent letters (Best & Kahn, 2003), the senior educators and principal completed the LeSTE for each of the 20 potential participants and gave these to the researcher. Analysis of the LeSTE revealed that five potential participants had to be excluded from the study as they did not meet certain of the stipulated criteria (i.e. two had physical disabilities that affected their ability to use their hands, one could not follow instructions and listen to an explanation without interrupting and two did not understand the LoLT as yet). Fifteen potential participants assented to participating in the study and each child then completed the pre-intervention assessment. Of these potential participants, seven were excluded as they did not meet the selection criteria. The participant list comprised the remaining eight participants and pseudonyms were assigned to them to protect their identity. The pre-assessment results (as well as the intervention results) were given to parents on completion of the study (Appendix AC). One participant was, however, then excluded as a stable baseline during the initial baseline tests could not be obtained. Hence, seven participants participated in the study.

3.6.3 Participant description

Participant 1: An English-speaking female who was 9;10. She presented with a generalised developmental delay but no sensory, gross motor or fine motor difficulties were reported. She was independent in terms of mobility and self-care. She had been at the school for three months.

Participant 2: A male of 11;5 whose first language was English. He presented with low-functioning academic ability. No sensory, gross motor or fine motor difficulties were reported. He was independent in terms of mobility and self-care. He had been at the school for one year.

Participant 3: A male of 9;7 whose first language was SiSwati. He had been diagnosed with Autism Spectrum Disorder (ASD) but no sensory, gross motor or fine motor difficulties were reported. He was independent in terms of mobility and self-care. He had been at the school for three years.

Participant 4: A male of 11;6. His first language was isiZulu and he presented with a learning disability. No sensory, gross motor or fine motor difficulties were reported. He was independent in terms of mobility and self-care. He had been at the school for one year but had attended an English-medium school prior to that for three years.

Participant 5: A female aged 9;10 whose first language was English. Her primary diagnosis was Down syndrome and she wore glasses for myopia. No difficulties related to gross or fine motor skills were reported. She was independent with regards to mobility and self-care. She had been at the school for three years.

Participant 6: An English-speaking female aged 9;1. Her primary diagnosis was ASD but no sensory, gross motor or fine motor difficulties were reported. She was independent in terms of mobility and self-care. She had been at the school for 10 months.

Participant 7: A male aged 10;8 whose first language was isiZulu. His primary diagnosis was low-functioning academic ability. No sensory, gross motor or fine motor difficulties were reported. He was independent in terms of mobility and self-care. He had been at the school for one month; prior to that he was enrolled at an English-medium school for four years.

All of the children at the school, including children who were participants in the study, were exposed to PCS symbols during lessons to label nouns within the classrooms but none of them received any AAC intervention at school. Table 3.5 provides a summary of the information about each participant as well as the scores they achieved in the pre-experimental assessment.

3.7 Equipment and materials

3.7.1 Equipment

3.7.1.1 Video-recording equipment

Two Panasonic SDR-s71 video cameras were used to record the intervention process and the probe sessions. Two camera tripods (one Giottos VT305 and one MiVision DS Series MI-3730) were used to mount the video cameras for the duration of the study. SD video camera memory cards were used to record the sessions.

3.7.1.2 Stationery

One sharpened HB pencil was available to each participant during the intervention phase and probe tests with which to indicate solutions to word-problems. In each scenario, solutions were indicated by drawing a circle around the calculated solution.

3.7.1.3 Furniture

Standard two-seater student tables with a metal frame and wooden top and standard student chairs that had a metal frame and plastic seat were used.

Table 3.5 Description of participants identified for the main study (n=7)

Pseudonym	**Participant 1**	**Participant 2**	**Participant 3**	**Participant 4**	**Participant 5**	**Participant 6**	**Participant 7**
Gender	Female	Male	Male	Male	Female	Female	Male
Chronological Age	9.10	11.05	9.07	11.06	9.10	9.01	10.08
First Language	English	English	SiSwati	isiZulu	English	English	isiZulu
Primary diagnosis	Generalised Developmental Delay	Low-Functioning Academic Ability	ASD	Learning Disability	Down syndrome	ASD	Low-Functioning Academic Ability
Therapeutic intervention	None	None	Speech therapy weekly at school	None	None	None	None
Extra-murals attended	Horse-riding once per month, Active Kidz once per week	Horse-riding once per month, Active Kidz once per week, soccer once per week	Horse-riding once per month, Active Kidz once per week, soccer once per week	Horse-riding once per month, Active Kidz once per week	Active Kidz once per week	Horse-riding once per month, Active Kidz once per week	Active Kidz once per week, soccer once per week
Attendance duration at current school	3 months	1 year	3 years	1 year	3 years	10 months	1 month
Physical impairments	No difficulties	No difficulties	No difficulties	No difficulties	No difficulties	No difficulties	No difficulties
Sensory Impairments	No difficulties	No difficulties	No difficulties	No difficulties	Glasses – myopia	No difficulties	No difficulties
Gross Motor Skills	No difficulties	No difficulties	No difficulties	No difficulties	No difficulties	No difficulties	No difficulties
Fine Motor Skills	No difficulties	No difficulties	No difficulties	No difficulties	No difficulties	No difficulties	No difficulties
Adaptive behaviours (Daily routine)	Independent in terms of mobility and self-care	Independent in terms of mobility and self-care	Independent in terms of mobility and self-care	Independent in terms of mobility and self-care	Independent in terms of mobility and self-care	Independent in terms of mobility and self-care	Independent in terms of mobility and self-care
Intelligence Quotient (KBIT-2)	56	61	60	49	48	59	40
Receptive language age equivalent score (Peabody Picture Vocabulary Test-4)	5.00	7.05	4.02	5.11	4.02	4.02	4.02

Table 3.5 Description of participants identified for the main study (n=7) cont.

Pseudonym	**Participant 1**	**Participant 2**	**Participant 3**	**Participant 4**	**Participant 5**	**Participant 6**	**Participant 7**
Numerical operations age equivalent score (WIAT-II)	5.08	7.00	5.08	7.00	5.08	6.00	6.08
Mathematical reasoning age equivalent score (WIAT-II)	5.00	5.08	4.04	6.00	5.04	5.04	4.00
Informal Counting Test	100%	100%	100%	100%	100%	100%	100%
PCS symbols Identification Test	100% after 4th day	100% after 4th day	93.6% after 4th day	100% after 4th day	93.6% after 4th day	93.6% after 4th day	93.6% after 4th day
History of AAC exposure	Exposure during lessons in the form of labels	Exposure during lessons in the form of labels	Exposure during lessons in the form of labels	Exposure during lessons in the form of labels	Exposure during lessons in the form of labels	Exposure during lessons in the form of labels	Exposure during lessons in the form of labels

3.7.2 Materials

3.7.2.1 Learner Screening Tool by Teachers (LeSTE)

The LeSTE (see Appendix F) was a checklist compiled by the researcher to gather information about potential participants, as delineated in Section 3.6.2 and Table 3.4. The aim of the LeSTE was not to be a diagnostic tool but an initial screening tool to identify potential participants given the time intensive nature of the full battery of tests used in this study. The development of the LeSTE is described in Table 3.6.

3.7.2.2 Kaufman Brief Intelligence Test – Second Edition (KBIT-2)

The KBIT-2 (Kaufman & Kaufman, 2004) was selected as it had been previously used in the African context to measure the IQ composite scores of South African children (Dada et al., 2013). It is a brief measure of verbal and nonverbal intelligence that is administered individually and can be used with individuals between the ages of 4;0 and 90;0 . The Verbal scale which measures crystallised ability comprises the Verbal Knowledge and Riddles subtests. The Nonverbal scale measures fluid reasoning and comprises the Matrices subtest. The IQ composite score provides an indication of an individual's overall functioning.

3.7.2.3 Peabody Picture Vocabulary Test – Fourth Edition (PPVT-IV)

The PPVT-IV (Dunn & Dunn, 2007) measures the receptive vocabulary of children and adults. Children were given a spoken word while being shown four line drawings simultaneously. Children were required to point to the line drawing that depicted the spoken word. Age-equivalent scores can be determined and reported. It was selected for its use as a receptive vocabulary test within the South African context (Dada, 2004).

Table 3.6 Development of the Learner Screening Tool by Teachers (LeSTE)

Aims	Method	Results	Recommendations
1. To develop a comprehensive checklist of factors that could influence children's learning.	Google Scholar and the UP library website were used to search for learning difficulty/disability checklists for children. The 8 found were pertinent to identifying common domains that could help identify difficulties related to learning. These 8 checklists were thus examined and compared.	Domains that appeared on more than 3 checklists were regarded as common. These included: i) Gross motor ii) Fine motor iii) Cognition iv) Attention and concentration v) Language vi) Reading vii) Writing viii) Mathematics ix) Social and Emotional	Factors relevant for this study and to be included in the LeSTE are: vision, hearing, motor skills, cognition, language of learning and teaching and PCS symbols knowledge.
2. To ensure that: a) The LeSTE had face validity.	The LeSTE was presented for discussion to a panel of 13 professionals for perusal. Their professional backgrounds included counsellors, learning support specialists, occupational therapists, psychologists, speech and language therapists and audiologists and teachers. Input from the 3 teachers who completed the LeSTE prior to the first pilot study was also taken into consideration to modify the checklist.	The LeSTE is intended to consider skills that are required for children to be able to participate in the MAiLgS programme optimally. The panel found the LeSTE to have adequate face validity.	No changes were recommended to increase face validity.

Table 3.6 Development of the Learner Screening Tool by Teachers (LeSTE) cont.

Aims	Method	Results	Recommendations
b) The factors included in the LeSTE were comprehensive.		While an interminable list of all the factors could be developed, only those appropriate to the MAiLgS programme were included. The 9 domains identified as common from the 8 checklists examined were re-examined to identify the factors pertinent to this study. These factors included: i) Fine motor ii) Cognition iii) Language iv) Mathematics Other factors not found in the checklists examined but deemed to be relevant to this study and that were used included: i) Vision and hearing ii) Exposure to PCS symbols	Following the panel discussion, limiting vision to 2 criteria instead of the initial 4 was suggested. The questions **can the learner see visual objects in front of the classroom from his/her desk?** and **can the learner see pictures, symbols or words in a book s/he is holding?** were moved to the Cognitive domain, as the identification of stimuli requires cognitive skills and thus does not test vision. For hearing, one criterion was moved to the Cognitive domain, namely **can the learner follow instructions?** since this question did not truly test the hearing of learners but rather tested memory. The remaining criteria for motor skills, LoLT and PCS symbols were retained. The teachers included in the pilot study suggested including attention and concentration items in the LeSTE instead of a separate standardised checklist, since diagnosing attention and concentration difficulties are not required in this study. As a result, 2 further questions were included in the Cognitive domain (**can the learner listen to an explanation without interrupting? and can the learner concentrate on a task for 20 minutes?**)
c) The layout of the LeSTE was user-friendly and the statements were clearly formulated.		The LeSTE was developed into a table format and the numbering was initially restricted to each section. Columns to mark “yes” or “no” responses were provided next to each criterion.	The panel recommended consecutive numbering across sections. The table layout was deemed to be user-friendly and the statements unambiguous. The teachers found the consecutive numbering to be user-friendly and the statements clear. No changes were thus needed.
3. To determine the ease of data coding.	The LeSTE was presented to a qualified statistician.	The statistician found the coding process to be easily coded.	The statistician recommended adding the gender and primary diagnosis of the potential participant to the LeSTE, which was done.

3.7.2.4 The Wechsler Individual Achievement Test – Second Edition (WIAT-II)

The WIAT-II (Wechsler, 2005) is a comprehensive test to assess the achievement of children and adolescents. The WIAT-II includes tests for reading, writing, mathematics and oral language. Although the mathematical tests have not been used within a South African context, research using the writing tests suggests that it is a reliable and appropriate test of academic writing ability (Maher, 2011). Only the tests for mathematics were used for this study, however. They specifically test the ability to solve written mathematical problems using the four operations as well as the ability to reason mathematically in order to solve word problems. Age-equivalent scores can be determined and reported.

3.7.2.5 Informal counting test

The Informal Counting Test (Appendix J) was developed by the researcher following Pilot Study 1, which revealed that one participant could not count the manipulatives (counters) used to solve the word-problems accurately. The Informal Counting Test requires participants to count out randomly presented numbers of manipulatives. This is crucial to being able to count the manipulatives when solving the word-problems. In this way errors in calculations cannot be attributed to counting errors. A criterion of 100% accuracy was required of participants.

3.7.2.6 PCS symbols Identification Test

The PCS symbols Identification Test (Appendix I) was developed by the researcher (see Section 4.4.2). It consisted of the 36 matrix PCS symbols used during the MAiLgS programme. It comprised a 36-PCS symbols overlay. The test was administered individually and involved each participant pointing to the PCS symbols that represented the vocabulary item in response to the question *which picture do you think shows SWEETS?* for example. If a participant was unable to identify the PCS symbol that represented a specific vocabulary item, the researcher modelled the item thereby pointing to the PCS symbol while simultaneously providing the spoken word for the PCS symbol { *SWEETS sweets*}. The participant was then asked about the next PCS symbol, until each PCS symbol had been worked through. The PCS symbols Identification Test was repeated over four days with each participant. A criterion of 90% correctly identified PCS symbols on the fourth day was used as the criteria for inclusion in this study. The development of the PCS symbols Identification Test is described in Section 4.4.2.

3.7.2.7 Facilitator board

The facilitator board (Figures 3.1 and 4.2) that was developed by the researcher was used during the intervention phase. It was used to provide MAiLgS to a group of participants. The facilitator board measured 1 000mm x 900mm and included 36 PCS symbols and 11 numerals printed in colour. The development and structure of the facilitator board is described in more detail in Section 4.4.4.

3.7.2.8 MAiLgS programme script

A MAiLgS programme script (Appendices K, L &M) was developed by the researcher for each of the three types of word-problem to guide the teaching of the word-problems. The script was developed to ensure procedural integrity. The development of the script is described in Section 4.4.3.

3.7.2.9 Probe scripts

Probe scripts (Appendices N, O & P and Figure 3.1) were developed by the researcher to ensure procedural integrity during administration of the probe tests during the baseline, intervention and maintenance phases. The probe test questions to be solved by participants were read aloud twice (e.g. *ZINZI HAS 7 SWEETS. Then she GIVES SOME to JOE. Now ZINZI HAS 2 SWEETS. HOW MANY SWEETS does ZINZI GIVE to JOE?... ZINZI HAS 7 SWEETS. Then she GIVES SOME to JOE. Now ZINZI HAS 2 SWEETS. HOW MANY SWEETS does ZINZI GIVE to JOE?*). The scripts were presented in a table format and each word-problem for the three word-problem types was printed in the colour that matched the coloured symbols on the probe test answer sheets used by participants.

3.7.2.10 Probe answer sheets

The probe answer sheets (Appendices Q, R & S and Figure 3.1) comprised the six word-problems that were taught for each of the three word-problem types during the intervention phase. They were printed in three colours (red, blue and purple) to indicate the change, combine and compare subtraction word-problem types suggested by Riley et al. (1983) respectively. The word-problems were randomly presented and numbered using pictures so that participants were not confused by numerals (e.g. a red motorbike instead of the numeral). After the researcher read a word-problem out loud, participants were instructed to work out the answer to the word-problem and circle their solution to each word-problem from 11 possible solutions ranging from 0 to 10 (presented in numeral form) on the probe answer sheets. Participants were given a new probe answer sheet for each probe test.

3.7.2.11 Concrete apparatus to solve word-problems

In keeping with the guidelines of Riley and Greeno (1988), concrete apparatus was used to demonstrate word-problem solving. This apparatus comprised a laminated A3 replica of the facilitator board, which included a red and purple calculation mat and 20 opaque, convex, flat-based manipulatives that could be used to find the solution to the word-problems as depicted in Figure 3.1. The adapted version of Riley and Greeno's (1988) apparatus is explained in Section 4.4.5.

Figure 3.1 MAiLgS programme materials

3.8 Data collection procedures

3.8.1 General data collection procedures

Ethical approval was obtained from the University of Pretoria to conduct this study (Appendix A). Thereafter, permission to conduct this study at the school described below was obtained from the school principal (Appendix B) and teachers (Appendix C). Parents of all 80 children in the school were given a newsletter from the principal that explained the study, although only 34 consent letters were sent to parents of children who potentially met the selection criteria to request consent for their children to be considered for the study. Fourteen children were excluded as their consent forms were not returned.

Next, the LeSTE (Appendix F) referred to in Tables 3.2, 3.3, 3.5 and 3.6 was completed for 20 children by senior teachers and the principal to identify potential participants who met the participant selection criteria. On receiving the completed LeSTE forms, assent was obtained from the children themselves (Appendix E) to ensure that they were agreeable to participating in the research, in keeping with sound ethical practices (Babbie & Mouton, 2003). Of the 20 children five were excluded after they did not meet the criteria stipulated in the LeSTE. The remaining 15 children underwent the pre-intervention assessment and seven were excluded as they did not meet the participation selection criteria. Although eight children participated in the initial baseline probes, one child was excluded due to an instable baseline. This resulted in seven children participating in the study.

3.8.2 Description of the setting

The largest classroom in the school that was situated at the end of the passage was used to conduct this study to allow for minimal disturbance. The classroom is painted white and has four windows that provide sufficient lighting and ventilation. The classroom has two entrances, one leading in from the passage and one leading out to the playground. Each participant used a two-seater table and a chair for the intervention process and probe tests. Arranging tables in the kidney shape advocated by Goossens' (2000) and Bornman and Rose (2010) was not possible and the tables were thus placed in two rows of four tables each. The eight participants were each seated at their own table (Bornman & Rose, 2010; Goossens',

2000) with the researcher seated in the middle alongside the facilitator board. One video camera was positioned facing the participants, slightly higher than the level at which they were seated, to record their actions and word-problem solving methods, while the second video camera was positioned behind the participants in such a manner that both the facilitator board and the researcher were recorded.

3.8.3 Pre-intervention assessment

The researcher conducted the pre-intervention assessment individually with potential participants with two assessment tasks being done each day with each potential participant. This involved each potential participant being assessed over a period of three days and all 15 potential participants were assessed in one week. The pre-intervention assessment involved administering the intelligence test to determine whether potential participants met the IQ between 40 and 69 specified for this study. Thereafter, the PPVT-IV was administered to evaluate receptive vocabulary, in which the participants needed to score between 4;0 and 8;0. The WIAT-II numerical operations and mathematical reasoning subtests were administered to measure each participant's mathematical skills, which also had to score between 4;0 and 8;0. The standardised tests provided descriptive information regarding each participant's age-equivalent functional level. An informal test to determine whether participants could count out 100% of the given number of manipulatives was done (Appendix J). Finally, the PCS symbols Identification Test (Appendix I) was presented to participants to determine their ability to correctly identify 90% of the PCS symbols after four days, given the central function of the PCS symbols in the intervention programme. Seven participants were excluded on completion of the pre-intervention assessment as they did not meet the participant selection criteria.

3.8.4 Probe tests

The purpose of the initial baseline probes (Appendices N & Q) was to establish the level of performance of each participant prior to the introduction of the intervention (Murphy & Bryan, 2001). The baseline, according to Gast and Ledford (2010) and Horner and Baer, (1978), assesses the change, combine and compare word-problem types under study during single sessions at the start of the study. In this study, eight participants completed the three initial baseline measures using the probe test in a small-group setting; although one participant had to be excluded due to the baseline probe tests being instable. During the intervention phase, participants completed a probe test after each session in the same way as the initial baseline (Appendices O & R). Following the three-week intervention phase, there was a withdrawal period of four weeks. Three maintenance probe tests were then conducted in the same way and using the same format as the initial baseline and intervention probe tests (Appendix P & S).

Each probe test included 18 word-problems that were randomly presented so that each type was not clustered (Carpenter & Moser, 1984). The sentence length, syntax and vocabulary level of the word-problems were kept as similar as possible in order for them to be equivalent (Carpenter & Moser, 1984). The researcher read each word-problem twice (Cummins, 1991; Schumacher & Fuchs, 2012) (e.g. *ZINZI HAS 7 SWEETS then SHE GIVES SOME to JOE. Now ZINZI HAS 2 SWEETS. HOW MANY SWEETS does ZINZI GIVE to JOE? ZINZI HAS 7 SWEETS then SHE GIVES SOME to JOE. Now ZINZI HAS 2 SWEETS. HOW MANY SWEETS does ZINZI GIVE to JOE?*) Participants were then required to solve the word-problems using the manipulatives and calculation mats while the large facilitator board was positioned in the front of the room for the intervention phase. Although the facilitator board was available, participants did not receive MAiLgS during the probe tests

(Harris & Reichle, 2004). The word-problem answers only fell within the number range zero to 10, since working within the smaller number range minimised calculation errors and would more accurately reflect the participants' ability to solve the word-problems (Riley & Greeno, 1988). After each answer was calculated, the participants searched for and circled the appropriate answer on the relevant probe answer sheet. Noncontingent reinforcement such as *good job* or *keep going* was provided to encourage participants to persevere with the activity (Nigam, Schlosser & Lloyd, 2006). On completion of the probe tests, participants were allowed to choose a sticker as a reward for their efforts.

Once stable baselines were achieved for participants, intervention was initiated. The baseline was regarded as stable when three consecutive scores did not vary by more than one point either positively or negatively. It was, however, necessary to commence with the intervention programme despite some participants not achieving a stable baseline, due to the teaching criterion set for this study.

3.8.5 Intervention

The intervention and probe phases of the study were implemented using a small-group format, which is one teaching strategy advocated by the Department of Basic Education for the teaching of mathematics and, inherently, word-problem solving (DoE, 2011) and which is regarded as more consistent with clinical practice (Dada & Alant, 2009). The small-group format was selected since it allowed the researcher to lead the learning process for children having similar needs (Bornman & Rose, 2010). This ensured that the participants were exposed to the MAiLgS programme in the same way (Dada & Alant, 2009) and thus facilitated the systematic step-by-step strategy to teach word-problem solving (Saunders, Bethune, Spooner & Browder, 2013). It also had the benefit of the children working cooperatively (Dada & Alant, 2009) in terms of completing the same word-problems simultaneously.

The first week of intervention entailed implementation of the MAiLgS programme for the change word-problem type. Week 2 focused on the combine word-problem type and the third week covered the compare word-problem type. Each week, participants were exposed to one intervention session on a daily basis for five consecutive school days. To prevent fatigue from setting in and in keeping with the school's timetable, all sessions were conducted early in the morning. Each session lasted approximately 40 minutes and was video recorded.

Participants were exposed to each word-problem type using the MAiLgS programme. The same six word-problems were taught in each of the five sessions each week. A total of 18 word-problems were taught by the end of the MAiLgS programme. During the intervention phase the MAiLgS programme script was followed to ensure procedural integrity (Appendices K, L & M). The researcher used the facilitator board, manipulatives and a pointer to teach each word-problem, while the participants only had the intervention answer sheets and a pencil on their tables. After completion of each taught word-problem participants independently found and circled the correct answer on the intervention answer sheets. If participants reported difficulties in understanding the word-problem or if difficulties were observed with a given word-problem it was repeated before moving on to the next. Following a break, probe answer sheets, A3 facilitator board replicas and manipulatives were placed on the participant's tables (Figure 3.1). Participants completed the probe tests after the break.

3.9 Data analysis

The data collected for this study was interpreted in order to determine whether the main aim of the study had been achieved. The video recordings, MAiLgS scripts, probe scripts, probe answer sheets completed by each participant and the general probe test and intervention checklists were used for data analysis purposes. The results of the probe tests were presented graphically and visually analysed (Gast & Spriggs, 2010). Thereafter, statistical analysis was conducted using statistical strategies for single-subject designs (Horner & Baer, 1978; Schlosser, 2003). This included determining the percentage of nonoverlapping data (PND) (Scruggs & Mastropieri, 2001), and the improvement rate difference (IRD) (Parker et al., 2009) which was calculated using StatsDirect software (Version 3) (Buchan, 2000).

3.9.1 Procedural integrity

Procedural integrity was calculated to ensure that the intervention was implemented properly and in "sufficient dosage levels" (Kratochwill et al., 2010, p. 34) (Appendices W & X). The researcher determined the procedural integrity for all the general procedures used and adherence to the programme scripts. The inter-rater then randomly selected and observed 33% of the initial baseline session videos, 40% of the randomly selected videos for the intervention sessions and 33% of the maintenance probe session videos to independently measure procedural integrity. Procedural integrity for the probe and intervention sessions in terms of general procedures and script adherence was calculated using the formula of Kuoch and Mirenda (2003, p. 222):

$$\frac{\text{number of correct steps executed by the researcher}}{\text{total number of possible steps}} \times 100$$

3.9.1.1 Procedural integrity of general procedures during probe sessions

The general procedures for each probe sessions were rated using the above formula. Accordingly, the researcher calculated procedural integrity for all the session as 296/336 x 100 with a mean percentage of procedural integrity for the probe sessions scoring at 88.2% and the inter-rater calculated procedural integrity for the randomly selected sessions as 110/128 x 100 with a mean percentage of procedural integrity for the probe sessions scoring at 86%.

3.9.1.2 Procedural integrity of general procedures during the intervention phase

The intervention phase general procedures were rated using the formula above. The researcher calculated procedural integrity for all of the intervention sessions to be 338/360 x 100 with a mean percentage of procedural integrity for the intervention sessions scoring at 94.1% while the inter-rater calculated this as 139/144 x 100 = 96.5%.

3.9.1.3 Procedural integrity of adherence to the probe scripts

Adherence to the scripts during the probes sessions was evaluated using the formula of Kuoch and Mirenda (2003, p. 222):

$$\frac{\text{number of correct steps executed by the researcher}}{\text{total number of possible steps}} \times 100$$

Probe test script adherence (Appendix Y) was calculated by the researcher to be 286/288 x 100 = 99.3%. The inter-rater calculated procedural integrity for probe test script adherence as 285/288 x 100 = 99%.

3.9.1.4 Procedural integrity of adherence to the MAiLgS programme scripts

MAiLgS programme adherence during the intervention phase sessions was evaluated using the formula of Kuoch and Mirenda (2003, p. 222):

$$\frac{\text{number of correct steps executed by the researcher}}{\text{total number of possible steps}} \times 100$$

Adherence to the MAiLgS programme scripts (Appendices Z, AA & AB) was calculated by the researcher to be 1311/1344 x 100 = 97.5% for change-type word-problems, 952/972 x 100 = 97.9% for combine-type word-problems and 1299/1308 x 100 = 99.3% for compare-type word-problems, yielding total procedural integrity for the MAiLgS programme script adherence as 3562/3624 x 100 = 98.3%. The inter-rater calculated procedural integrity of MAiLgS programme script adherence for the change-type word-problems as 1315/1344 x 100 = 97.8%, for the combine-type word-problems as 952/952 x 100 = 100% and for the compare-type word-problems as 1291/1308 x 100 = 98.7%. This yielded total procedural integrity for the MAiLgS programme script adherence as 3558/3625 x 100 = 98.2%.

3.9.2 Procedural reliability

After completing the procedural integrity scores for the general procedures and script adherence, inter-rater reliability was calculated for 40% of the sessions observed to measure the inter-rater's procedural integrity. This exceeded the 20% recommended by Kratochwill, Hitchcock, Horner, Levin, Odom & Rindskopf et al. (2012). The formula of Tawney and Gast (1984) was used to calculate inter-rater reliability:

$$\frac{\text{number of agreements between raters}}{\text{(number of agreements + disagreements)}} \times 100$$

i) General procedures during probe session inter-rater reliability score: 105/ (105+7) x 100 = 93.8%.

ii) General procedures during the intervention sessions inter-rater reliability score: 134 / (134 + 7) x 100 = 95.1%.

iii) Probe test script adherence inter-rater reliability: 285 / (285+1) x 100 = 99.6%.

iv) MAiLgS programme script adherence inter-rater reliability: 3 554 / (3 554 + 12) x 100 = 99.7%

3.9.3 Data reliability

Once the researcher had scored each of the probe answer sheets (Appendices Q, R & S), an inter-rater checked all of them to ensure that they had been scored correctly and that the totals had been recorded in the tally section accurately. This was important to ensure that the graphs developed for the participants were based on reliable information. Inter-rater reliability was then calculated using Tawney and Gast's (1984) inter-rater reliability formula (100 / (100 + 0) x 100 = 100%. There was thus 100% agreement between the researcher and inter-rater on the scoring of the probe answer sheets.

3.9.4 Frequency of MAiLgS

The MAiLgS programme script checklists (Appendices Z, AA & AB) delineated each phrase to be used during the teaching of the word-problems in the intervention phase. A checkbox preceded each phrase, and every word designated as an MAiLgS word (to be said and pointed to simultaneously) was capitalised. The probe script checklist (Appendix Y) comprised the 18 word-problems to be read to participants during the probe measures. This checklist made provision for scoring whether the word-problems were read twice, as well as other deviations from the scripted word-problems (e.g. words omitted or added).

To calculate the frequency of MAiLgS, the researcher used the MAiLgS programme script checklists (Appendices Z, AA & AB). Rating frequency of MAiLgS entailed determining the number of times that the capitalised words in the script were said and the corresponding PCS symbol pointed to simultaneously. Words said without the corresponding PCS symbol being pointed to were circled while words that were not said and the corresponding PCS symbols were not pointed to were struck through. The formula used by the researcher to calculate the frequency of MAiLgS was the same as the one used by the inter-rater, namely:

$$\frac{\text{number of times MAiLgS was provided}}{\text{total number of opportunities for MAiLgS}} \times 100$$

i) Change-type word-problems frequency of MAiLgS:

a) Researcher calculation: 1311/1344 x 100 = 97.5%

b) Inter-rater calculation: 1315/1344 x 100 = 97.8%.

ii) Combine-type word-problems frequency of MAiLgS:

a) Researcher calculation: 952/972 x 100 = 97.9%.

b) Inter-rater calculation: 952/972 x 100 = 97.9%.

iii) Compare-type word-problems frequency of MAiLgS:

a) Researcher calculation: 1299/1308 x 100 = 99.3%

b) Inter-rater calculation: 1291/1308 x 100 = 98.7%.

Thereafter, inter-rater reliability for the frequency of MAiLgS across the three types of word-problem was calculated using Tawney and Gast's formula (1984): 3554/ (3554 + 12) x 100 = 99.7%.

3.9.5 Nature of MAiLgS

Each phrase on the MAiLgS programme script checklists (Appendices Z, AA & AB) for the randomly selected sessions was read by the researcher and inter-rater independently. On the MAiLgS programme scripts checklists, question marks were placed before the checkboxes but statements were not marked. The number of statements and questions respectively were counted and converted to ratio scores to determine the statements-to-questions ratio. The researcher and the inter-rater both used this procedure. According to the researcher and inter-rater, the nature of MAiLgS for the change-type word-problems scored at 92:8 (statements: questions), for the combine-type word-problems it scored at 84:16 (statements: questions) and for the compare-type word-problems it scored at 92:8 (statements: questions). Inter-rater agreement was calculated using Tawney and Gast's (1984) formula as 36 / (36+0) x 100 = 100%, indicating that there was 100% agreement between the researcher and inter-rater regarding the nature of MAiLgS.

3.9.6 Visual analysis of data

Comparisons between each of the word-problem types and between participants were made based on visual analysis of the three graphs for each participant (Campbell & Herzinger, 2010; Gast & Spriggs, 2010; Horner, Swaminathan, Sugai & Smolkowski, 2012; Kratochwill et al., 2010, 2012). The graphs formed the basis for allowing visual analysis of whether the MAiLgS programme was effective in facilitating word-problem solving following intervention (Nigam et al., 2006). This was done using the six features – level, trend, variability, immediacy of effect, overlap and consistency of data patterns – advocated for single-case intervention research (Horner et al., 2012; Kratochwill et al., 2012). This type of visual analysis requires data to demonstrate a minimum of "three indications of an effect at different points in time", which would imply a causal relation between manipulation of the independent variable and changes in the dependent variable (Kratochwill et al., 2010).

3.9.7 Statistical analysis

Although there is no consensus regarding appropriate effect-size methods for single-case designs, calculating the effect size is nonetheless advocated to supplement visual analysis (Kratochwill et al., 2012). Two possible statistics reviewed for single-case designs include percentage of PND and IRD (Maggin, Chafouleas, Goddard & Johnson, 2011).

For this study, the PND was used due to its widespread application in single-case designs (Scruggs & Mastropieri, 2013). The PND determines the difference between the highest baseline score and the number of intervention points that scored above that (Gast & Spriggs, 2010; Olive & Smith, 2005; Schlosser, Lee & Wendt, 2008; Scruggs & Mastropieri, 2010, 2013). The PND was calculated using the formula:

$$\frac{\text{Number of data points within a phase where \% correct responses is higher than highest \% achieved during baseline}}{\text{Total number of data points for this phase}}$$

Thereafter, the effect size of the treatment was also calculated using the improvement rate difference (IRD), which gives an indication of the percentage of improvement between the baseline and intervention performance (Parker, Vannest & Brown, 2009; Waddell, Nassar & Gustafson, 2011). The IRD was determined by identifying the IR for each phase using the formula:

$$\frac{\text{number of improved data points}}{\text{total number of data points}}$$

The IRD was then calculated using the formula:

$$IR_T – IR_B = IRD$$

where IR_T refers to the improvement rate during the treatment and IR_B was the improvement rate during the baseline (Parker et al., 2009, p.138; Waddell et al., 2011). The confidence intervals at 90% were calculated using the StatsDirect 3 software (Buchan, 2000).

3.10 Conclusion

This chapter delineated the research methodology used for this study. The main aim and subaims were stated and the research design used was explained and justified. The pre-experimental phase was described in terms of the development of the intervention in the form of a MAiLgS programme to be implemented, materials and the two pilot studies in terms of their objectives, methods (procedures and measures), results and recommendations. The experimental phase of this study involved the identification of participants, pre-intervention assessment, baseline probe tests, implementation of the intervention, probe tests, maintenance phase and subsequent maintenance probe tests. Next the data collection process was explained and the chapter ended with a discussion of the analysis of the data obtained as well as issues related to reliability of the measures.

CHAPTER 4

MAiLgS PROGRAMME DEVELOPMENT

4.1 Introduction

This chapter aims to outline the development of the MAiLgS programme. Employment of AiLgS principles (Goossens', 2000) within an adapted version of the Augmentative and Alternative Communication Input Framework (AACIF) (Wood et al., 1998) to teach word-problem solving to children with intellectual disabilities is undertaken. The word-problem solving model of Riley et al. (1983) is combined with AiLgS principles and referred to as mathematical aided language stimulation (MAiLgS). The contribution and application of these three constructs are explored within the theoretical framework of the MAiLgS programme. The constructs of this programme are schematically represented in Figure 4.1. The MAiLgS programme, which is the independent variable in this study, is described and discussed, as are the materials used in the implementation of the programme.

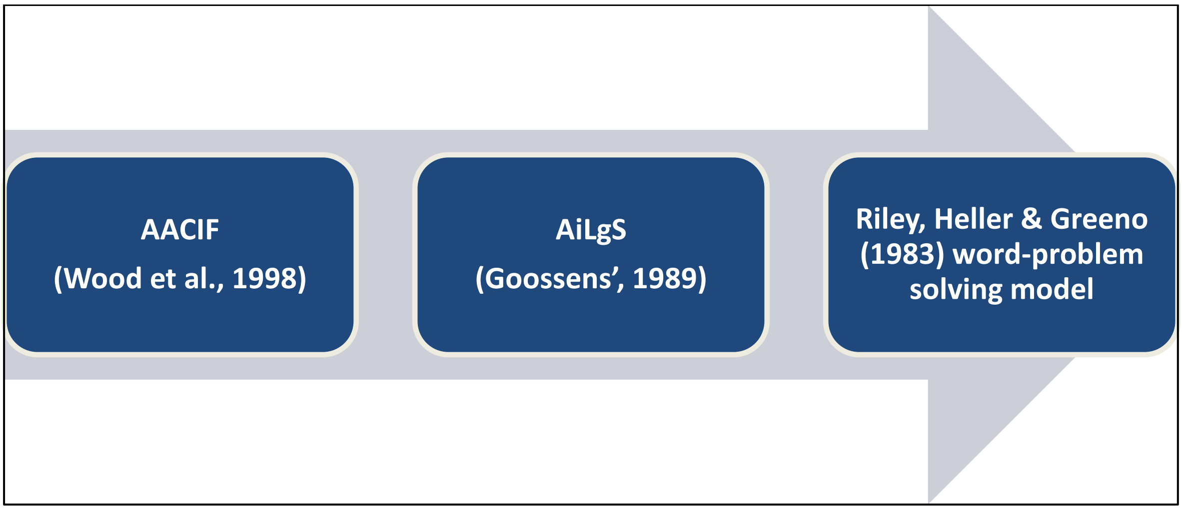

Figure 4.1 MAiLgS programme constructs

4.2 Theoretical framework of the MAiLgS programme

Consultation of the literature pertaining to mathematical word-problem solving reveals an emphasis on developing word-problem solving skills as they relate to solving problems in daily life (see Sections 2.2 and 2.3). While there is a wealth of research on developing these skills for learners who have mathematical disabilities, there seems to be a paucity of research that explores developing these skills for children with intellectual disabilities. Consequently, this study proposes a programme that is intended to teach word-problem solving to learners with intellectual disabilities. It is contended that three particular constructs can be integrated into the MAiLgS programme so as to optimise word-problem solving skills for children with intellectual disabilities. It is thus hypothesised that the aided input strategy of AiLgS within the scope of the AACIF may be employed in conjunction with the linguistically oriented word-problem solving model of Riley et al. (1983).

The first construct refers to the AACIF framework (Wood et al., 1998) as the overarching structure. The second construct is the operationalisation of AiLgS principles (Goossens', 1989) to teach the word-problems. The third construct is the word-problem solving model of Riley et al. (1983) to provide a structure for the word-problems. MAiLgS integrates these three constructs and consequently may be defined as an intervention that provides spoken input for mathematical word-problems while simultaneously pointing to the corresponding PCS symbols and modelling the solution process using manipulatives.

4.3 Constructs of the MAiLgS programme

4.3.1 The AACIF

Wood et al. (1998) developed the comprehensive AACIF for AAC users, which emphasises how strategies may be used to augment spoken language input. This framework thus elucidates upon the processes that take place during augmented input. Application of the framework occurs in a sequential manner whereby the AAC user becomes progressively more capable of interacting independently and accurately. It stipulates four components of aided input. The appeal of the AACIF for word-problem solving rests in its attention to the language used, comprehension and retention of the word-problem as well as exposure to possible solutions that facilitate solving the word-problem. Table 4.1 provides an adapted version of the table presented by Wood et al. to delineate the four components as they apply to word-problem solving. The text in boldface represents additions or modifications to the original table as they apply to this study.

The first component describes augmenting the message and as such is related to comprehension of the language used. The goal of this component is to enhance and strengthen the meaning and salience of the words used during the interaction by incorporating graphic symbols related to the spoken words (Loncke et al., 2006). This component is effected during the first phase of MAiLgS where the emphasis is on the language used in the word-problems. In the teaching of word-problem solving, receptive language (which is a more recent focus of AAC intervention and primary to AiLgS) plays a pivotal role (Dada & Alant, 2009). Children are assisted in understanding the vocabulary used in the word-problem so that they are able to apply it to solve the word-problems (Lucangeli et al., 1998). The

Table 4.1 Adapted AACIF (Wood et al., 1998) for the teaching of word-problems to children with intellectual disabilities

Input Component	**Definition**	**Purpose**	**Assumptions**	**Area of focus**	**Teacher participation**	**Potential impact on children**	**Theoretical application to this study**
Augmenting the message	To enhance the meaning and salience of the immediate **word-problem**	To help **children** receive the **word-problem** information more accurately	**Children** have meaningful associations to the **word-problem** and symbols used by the **teacher**	**Comprehension of the language used during the verbalisation of the word-problem is important. Supporting comprehension with simultaneous exposure to PCS symbols is advocated**	The **teacher** presents the augmented **word-problem** (i.e. **orally with the PCS symbols being visible to children**)	**Children's** increased understanding of the **word-problem** improves the quality of the interaction **with the teacher while learning to solve word-problems**	**While verbalising the word-problems, the teacher speaks clearly so as to optimise what the children hear. As the word-problems are articulated, the associated PCS symbols are pointed to**
Mapping language and symbols	To help **children** associate symbols (**PCS symbols & spoken words**) with the environmental stimuli (**referents represented by PCS symbols**)	To help **children** learn language symbols (**PCS symbols**) more accurately	**Children** have a meaningful association to the referent and can retain this during the mapping process	**The principles of AiLgS are employed to teach word-problem solving. A teacher verbalises a word-problem while pointing to the PCS symbols that represent the words of the word-problem. Statements to teach word-problems comprise 80% of the interaction while questions or commands comprise 20%**	The **teacher** presents (maps) the associated symbol (**PCS symbols**) with the referent (**manipulatives used in word-problems**)	No immediate impact. Used as a learning strategy that has cumulative effects	**As the word-problem is articulated, the teacher points to the appropriate PCS symbols following the principle of using AiLgS 80% of the time with the statement: question instruction ratio being 80:20**

Table 4.1 Adapted AACIF (Wood et al., 1998) for the teaching of word-problems to children with intellectual disabilities cont.

Input Component	**Definition**	**Purpose**	**Assumptions**	**Area of focus**	**Teacher participation**	**Potential impact on children**	**Theoretical application to this study**
Augmenting retention	To facilitate **children's** recall of the event (**word-problem**) by referring to a symbol (**PCS symbols**) after delay	To help **children** retain information more accurately and for longer duration	**Children** have meaningful associations to the words and symbols (**PCS symbols**) used to augment retention	**How word-problems are processed impacts on the comprehension and solution. According to the dual coding theory both visual and auditory modalities are activated which promotes retention of word-problems.**	The **teacher** encourages reference to salient information by referring to the symbol during **teaching** and by prompting the **child** to indicate the symbol	The **teacher** receives a clearer understanding of the activity (**word-problem**) the **child** is trying to remember	**After the word-problem has been given, the selected PCS symbols may be referred to again as the teacher points to them and repeats their label to trigger recall of the given word-problem**
Developing a pool of response options	To encourage **children** to make selections from an array of choices or possible answers (**numbers**)	To help children express information more accurately (**solve word-problems**)	**Children** have meaningful associations to the items in the response pool (**possible solutions**). These associations may be temporary or permanent	**Providing children with possible solutions to word-problems is facilitated through concrete apparatus to demonstrate the subtraction process. This is in keeping with the principles of Riley et al. (1983)**	The **teacher** assembles the response pool (**possible solutions**), presents the response pool and responds to choices/answers children make	The **teacher's** understanding (**of children's understanding of the word-problem**) is enhanced by receiving specific information (**word-problem solutions**). The **children's** participation in the activity (**word-problem**) informs the **teacher** about their understanding and alertness (behaviour state)	**Children are presented with a pool of options that includes a choice of 11 possible solutions for the given word-problem**

word-problem solving model of Riley et al. (1983) is thus effective in this regard since children are able to form semantic models of the word-problem which facilitate their understanding of the language presented in the texts of word-problems. This in turn enables them to make the necessary inferences that support finding a solution (Carpenter & Moser, 1984). To this end, the models make use of the semantics of language to facilitate word-problem solving by getting children to model the semantic structure of the word-problem (Carpenter & Moser, 1984). To augment this process, children are simultaneously provided with auditory input (spoken) and visual input (PCS symbols). This means that children are consequently using more than one modality to comprehend the language of the word-problem (Goossens', 2000; Wood et al., 2008). Since both Goossens' (2000) and Wood et al. (2008) emphasise that the aim of this exposure should not be response-driven, children are afforded the opportunity to attend to the augmented input without having to simultaneously contemplate a suitable response.

The second component requires that the spoken words and graphic symbols are mapped. Here, the adult communicative partner points to the graphic symbols to enable the children to associate the graphic symbol with its referent. The implication is that for children to become proficient in using the graphic symbols independently to express themselves, they need to understand the meaning of these symbols. The second phase of MAiLgS incorporates this component of the AACIF with regard to mapping language and graphic symbols. This is done through application of the AiLgS principles as described by Goossens' (1989, 2000). During this phase of MAiLgS the goal deviates slightly from the second component of the AACIF. While the AACIF involves associating graphic symbols with their referents (Bloom, 1993; Goossens', 1989, 2000; Romski & Sevcik, 1993; Wood et al., 1998), in MAiLgS the goal is to associate the graphic symbols with the corresponding word-problem vocabulary, rather than a referent, to facilitate comprehension. The teacher thus points to the PCS symbols while simultaneously providing the spoken input of the word-problem and in so doing promotes maximum opportunity for exposure to language constructs in a natural manner (Goossens', 2000). This technique is reflective of the direct instruction discussed in Section 2.4.2, since children listen to the word-problem and the explanation of how it is solved while concurrently looking at the corresponding PCS symbols and observing the solution method using the manipulatives (Browder, Jimenez & Trela, 2012). A similar strategy was used to research the teaching of fractions to students in a remedial high school where the teacher demonstrated the solution using visual representation (Kelly, Gersten & Carnine, 1990).

Augmenting message retention is the third component, which focuses on making concrete representations of the interaction available in the form of graphic symbols. Children's recall of the interaction is enhanced since the graphic symbols serve to remind them of the interaction content. In terms of word-problem solving then, it is necessary to consider the way in which word-problems are processed and remembered since difficulties within these areas may impact negatively on children's word-problem solving (Carbonneau et al., 2013; Zheng et al., 2011; Swanson, Lussier & Orosco, 2013a). Accordingly, the third phase of MAiLgS operationalises the third AACIF component relating to augmenting message retention. Within this phase, Paivio's dual-coding theory (1980) and Baddeley's (1986) working memory model come into effect. It is important to bear in mind that word-problems are typically presented in written form in the classroom context. However, since children with intellectual disabilities may experience difficulties with reading word-problems (Fuchs & Fuchs, 2005), presenting the word-problems in graphic form (Paivio's imagens) instead can be expected to employ the same neurological processes (Van Balkom &

Verhoeven, 2010). This means that word-problems are represented by PCS symbols (instead of text) together with the spoken equivalent (Paivio's logogens) thereby requiring the information to be processed simultaneously (Loncke, Lloyd, van Balkom & Arvidson, 1999). Working memory, as discussed by Baddeley (1992), is expected to be facilitated using these supports and successful processing and retention should thus further facilitate word-problem solution.

The final component of the AACIF entails developing a pool of response options for the children. Different options that they can make meaningful associations with to facilitate the interaction should be available to the children for selection. Having processed a word-problem and retained it in memory, the final stage of MAiLgS entails solving it, which operationalises the fourth component of the AACIF. The difference is that while the AACIF focuses on providing possible responses that may be chosen to facilitate communication, the MAiLgS programme provides possible responses as potential solutions to the word-problems in the form of the numbers on the probe answer sheets. In both instances though, meaningful associations to the items in the pool need to be established to facilitate selection.

Comprehension of spoken language during interactions or instruction can be enhanced through augmented input using the AACIF (Wood et al., 1998) in the form of various aided input strategies. These strategies include AiLgS (Dada & Alant, 2009; Goossens', 1989, 1994, 2000), SAL (Romski & Sevcik, 1996), ALM (Drager et al., 2006) and Natural Aided Language (Cafiero, 1998), which were briefly delineated in Section 2.6.2. From these strategies AiLgS was specifically selected for its emphasis on receptive language skills (Goossens', 1989) and because it can be quantified and described for procedural integrity.

4.3.2 AiLgS principles

The underlying premise of the MAiLgS programme in this study is that language plays a critical role in a child's ability to solve subtraction word-problems. This premise is based on literature that explains that mathematics can be regarded as a language or register in itself, as discussed in Section 2.3.1.2 (Furner et al., 2005; Ma & Zhou, 2010; McKenzie, 2001). Hence, the MAiLgS programme aims to assist children with intellectual disabilities to understand word-problems using graphic symbols and spoken input.

AiLgS is utilised for its emphasis on the development of receptive language and thus comprehension of the language used (Dada & Alant, 2009; Goossens', 2000). The nature and frequency of augmented input is emphasised in order to develop receptive language. To this end, Goossens' (2000, p. 18) explains that children need to be exposed to graphic symbols being used interactively by seeing and hearing them over a period of time so as to master the ability to use them independently.

The implication for word-problems then is that in order for children to become familiar with the vocabulary used in word-problems, they should be exposed to this vocabulary, both in graphic symbol and spoken form, over a period of time. AiLgS has to be done 80% of the time in accordance with Goossens' (2000) principles (Goossens', Crain & Elder, 1994; Dada & Alant, 2009). Once this skill develops, children are more able to work through the word-problems independently using the graphic symbols to reflect their thinking of how to solve the word-problem. Furthermore, to achieve this goal, Goossens' stipulates that a ratio of 80:20 of statements: questions/commands needs to be achieved to ensure that children are exposed to sufficient information (Goossens', 2000). This also enables children to learn and come to understand the language of word-problems naturally (Beukelman &

Mirenda, 2013). Accordingly, augmented input from the teacher places emphasis on receptive language development prior to the development of expressive skills by children.

4.3.3 Word-problem solving model

In keeping with the direct instruction strategies that have proven to be effective for children with intellectual disabilities as described in Section 2.4.2, a teacher-driven strategy was selected for this study. Word-problem solving can be done with each of the four mathematical operations (Rockwell et al., 2011) and addition and subtraction are often operationalised in word-problem solving simultaneously (Department of Basic Education, 2011). However, children can be expected to be familiar with addition word-problems because they correlate with counting (Baroody, 1987, 1999). Consequently, only the aspects relating to subtraction are addressed in this study.

Both the models of Riley et al. (1983) and Briars and Larkin (1984) focus on addition and subtraction word-problems and were, therefore, considered for the word-problem structure in the MAiLgS programme. Both models comprise three stages of mathematical knowledge that are procedurally and structurally similar.

The Briars and Larkin model involves firstly translating words into groups of manipulatives that are representative of the quantities of the word-problem, whereby piles of manipulatives are set up to represent the word-problem quantities. Thereafter, the manipulatives are manoeuvred using both number facts pertaining to subtraction knowledge and counting strategies such as counting backwards or counting out those manipulatives to be removed. Finally, the answer is identified through counting the left-over manipulatives (Briars & Larkin, 1984).

Riley et al. (1983) developed their classification system for three types of addition and subtraction word-problems related to the level of difficulty of the word-problems (Carpenter & Moser, 1984; Riley & Greeno, 1988). The three levels of difficulty are presented in relation to the subtraction word-problems used in the current study in Table 4.2.

Table 4.2 Three types of subtraction word-problems

Word-problem type	Description	Example
1. Change	Change is unknown	*ZINZI HAS 7 SWEETS. She GIVES SOME to JOE. Now ZINZI HAS 5 SWEETS. HOW MANY SWEETS does ZINZI GIVE to JOE?*
2. Combine	Subset is unknown	*ZINZI and JOE HAVE 9 SWEETS TOGETHER. ZINZI HAS 4 SWEETS. HOW MANY SWEETS does JOE HAVE?*
3. Compare	Difference is unknown	*ZINZI HAS 6 SWEETS. JOE HAS 2 SWEETS. HOW MANY SWEETS does JOE HAVE LESS than ZINZI?*

From their study that tested the cognitive models involved in word-problem solving, Riley and Greeno (1988) concluded that the level of knowledge needed to solve change and combine word-problem types corresponded with the developmental and learning stages of children. Three hierarchical levels were observed to be operationalised when solving the progressively more difficult word-problems (Riley & Greeno, 1988).

Accordingly, to solve the word-problems of the Riley et al. (1983) model, the first step involves the word-problem being transformed from an external to an internal representation of the words. During this step, sets representing the word-problem are created. These are based on an appropriate schema of these sets in memory as well as the linguistic ability to map the wording of the word-problem in a way that allows the solution to be determined (Pellegrino & Goldman, 1987; Riley & Greeno, 1988). In the second step, cognitive representation of the word-problem based on the sets developed directly from the word-problem information is realised. It is in this step that Bruner's enactive mode is realised, since quantitative procedures that best represent the word-problem are decided upon.

Manipulatives are thus set out according to the word-problem structure to provide a concrete representation of the spoken and visually presented word-problem. The final step involves the actual solution of the word-problem. By physically moving the manipulatives according to the semantic model described by Riley and Greeno (1988), the subtraction process of a word- problem may be visually observed. The remaining manipulatives are counted to yield the solution of the word-problem that is presented within the response pool in numeral form, reflecting Bruner's symbolic mode.

4.4 MAiLgS programme material development

4.4.1 PCS symbols identification

To select the potential vocabulary that could be used in the MAiLgS programme to explain subtraction word-problem solving, the wording of the three types of word-problem of Riley et al. (1983) was used in their existing format. Thereafter, the researcher developed explanations of how each type of word-problem should be solved that would become the MAiLgS scripts used for each type of word-problem. The key words within each explanation were then identified. This process resulted in 45 words being identified, which in turn were reduced to 36 so as to fit into a 36-matrix (Goossens', 2000).

For the graphic symbols to be used on the facilitator board, PCS symbols were selected given that they have been commonly used in South Africa (Bornman et al., 2011; Dada et al., 2013; De Klerk et al., 2014; Haupt & Alant, 2003) and picture symbols are argued to be easier to learn than "arbitrary graphic symbols" (Stephenson, 2007, p. 44). The 36 key words as well as synonyms or variations were typed into the search box of the Boardmaker Plus Version 6 software to identify PCS symbols that could be used. Between two and four PCS symbols that could represent a specific vocabulary item were identified and saved, resulting in a total of 89 PCS symbols being identified. These 89 PCS symbols were arranged in a grid format according to verbs, descriptors, prepositions, nouns and miscellaneous words according to the adapted Fitzgerald key (Fitzgerald, 1949; Musselwhite & St. Louis, 1988). The background colours of the PCS symbols were in accordance with the convention of Goossens' (1994). Each symbol was numbered chronologically from left to right in the grid (Appendix G).

A peer panel that consisted of eight girls and seven boys was used to select 36 PCS symbols from the presented 89, which would be used on the facilitator board described in Section 4.4.4. These 15 typically developing children enrolled in Grade R were used as their cognitive level of functioning could be expected to most closely coincide with the main study participants who had intellectual disabilities (Dada et al., 2013). The peer panel was individually asked to *choose the picture that you think matches the word [vocabulary item] best*. The children pointed to the PCS symbol that they thought matched the word told to them and the number of the chosen PCS symbol for each vocabulary item was recorded in a table (Appendix H).

On completion of the exercise, the table was scrutinised to identify which symbol had been selected by most children for each vocabulary item. Of the 15 children, 12 preferred the plump form of symbols as opposed to stick figures. With regard to the colour of the figures, each child selected the colour of the figure that correlated with their own race (Mayer-

Johnson, 1981). For the children used in the word-problems, a girl and boy were decided upon to be representative of participants. The 36 PCS symbols selected by the peer panel were fitted into the 36-matrix (Goossens', 2000) and were printed in colour with the corresponding gloss typed in bold Grade One Font, point size 35, above the PCS symbol. These PCS symbols were used in the pilot studies, which required revisions of the vocabulary and PCS symbols as discussed in Tables 3.2 and 3.3. These revisions proceeded in the same manner as the initial PCS symbol selection process, using the peer panel again. The final version of the PCS symbols used is depicted in the facilitator board (Figure 4.2).

4.4.2 PCS symbols Identification Test

The PCS symbols identified by the peer panel were incorporated into the PCS symbols Identification Test (Appendix I) which was used for the selection of participants. The words depicted by the PCS symbols were used in the MAiLgS programme scripts (Appendices K, L & M). Following the two pilot studies, the PCS symbols Identification Test was revised and updated to include the new vocabulary.

4.4.3 MAiLgS programme script

The MAiLgS programme script was based on the structure of Riley et al.'s (1983) three types of word-problem for subtraction (Appendices K, L & M). The sentence structure for each type of subtraction word-problem was kept the same as Riley et al.'s in terms of sentence length and syntax. The names of the children used in the word-problems were, however, changed to include one girl and one boy. The items used in the word-problems were also changed from marbles to sweets. The solutions to the word-problems were limited to answers in the range 0 to 10 (Riley & Greeno, 1988). The word-problems were used as a basis for the MAiLgS programme scripts, where key words within each word-problem were identified and corresponding PCS symbols were identified for those words that would need graphic support when spoken. The key words that were depicted by PCS symbols were typed in capital letters in the MAiLgS programme scripts. The MAiLgS programme scripts developed were evaluated during each of the pilot studies and revised where necessary.

4.4.4. Facilitator board

The facilitator board that was developed measured 1 000mm x 900mm and had a black background to reduce the amount of competing background visual stimuli as far as possible. The 36 PCS symbols identified in Section 4.4.1 each measured 7.5cm x 6cm and were arranged in fixed vertical groups from left to right, starting with miscellaneous words, followed by verbs, descriptors, prepositions and nouns, using the guidelines of the Fitzgerald key (Fitzgerald, 1949; Musselwhite & St Louis, 1988). The backgrounds of the symbols were colour-coded to make them more distinct for participants while making them more easily accessible to the facilitator (Bornman & Rose, 2010). Accordingly, verb backgrounds were pink, descriptor backgrounds were blue, preposition backgrounds were green, noun backgrounds were yellow and miscellaneous word backgrounds were orange, in keeping with Goossens' (1994) convention. While not stipulated by Goossens', the background of numerals was grey to differentiate them from the other PCS symbols.

All symbols had a gloss above to ensure that they were not obstructed by the facilitator's hand while pointing to them during intervention. The Grade One font was used for the gloss to correlate with the emerging literacy skills of the children, where the form of a presented letter was consistent with the children's knowledge of the letter (e.g. presenting "a" instead of "a"). A variation of the traditional Goossens' board involved arranging the numerals above the other PCS symbols in the form of a number line to facilitate access to them. One red and one purple rectangular space with symbols of the children used in the respective word-problems were positioned on the right-hand side of the PCS symbols to facilitate word-problem solving. The facilitator board was laminated in a matte finish. The facilitator board is shown in Figure 4.2.

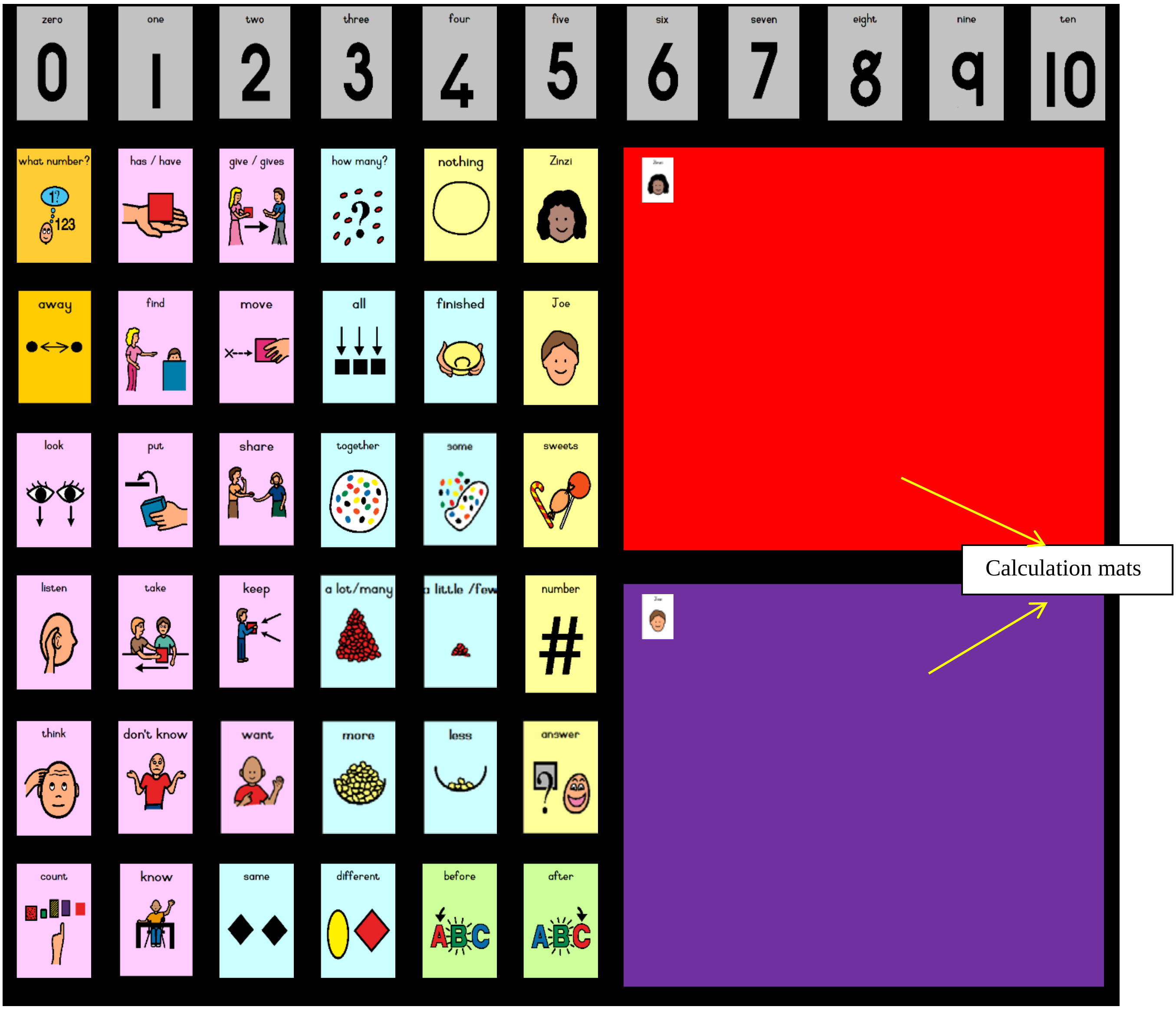

Figure 4.2 Facilitator board

4.4.5 Concrete apparatus to solve word-problems

According to Riley and Greeno (1988), children must be shown how to solve word-problems using two sheets of coloured cardboard, one green and one yellow. Although this guideline was followed, red and purple-coloured rectangles were used as part of the facilitator board and referred to as calculation mats. The colours were changed to red and purple to prevent confusion with the yellow and green background colours of the PCS symbols used on the facilitator board. The red calculation mat was assigned to Zinzi and the purple one was assigned to Joe. When solving the word-problems, manipulatives representing the sweets were put onto each child's calculation mat and moved as required to solve the word-problem.

Manipulatives are argued to support learning by facilitating abstract reasoning development, being representative of real-world knowledge and by improving the encoding of word-problems (Carbonneau et al., 2013; Saunders et al., 2013). As a result, manipulatives were used to encourage children to construct concrete representations that matched the semantic structure of the three types of subtraction word-problem (Carbonneau et al., 2013; Verschaffel & De Corte, 1993). Twenty opaque manipulatives that were 20mm in diameter, convex and with a flat base were used, as they were easy for the children to control. During probes participants each had 20 manipulatives to calculate the probe word-problems.

4.5 Conclusion

The focus of this chapter was on describing the development of the MAiLgS programme. It described the theoretical framework of the MAiLgS programme and explained the constructs that were incorporated into it. This included the employment of AiLgS principles within an adaptation of the AACIF and the word-problem solving model of Riley et al. (1983), which was used to structure the word-problems. The aim of the MAiLgS programme was to enhance the teaching of word-problems to children with intellectual disabilities.

CHAPTER 5

RESULTS

5.1 Introduction

This chapter delineates the results of the study with specific reference to sub aim vii, namely to determine whether the MAiLgS programme improves the subtraction word-problem solving skills of children with intellectual disabilities. This is done using three processes. The first process describes the procedural integrity, reliability of procedures and reliability of data used in the study. The second process involves describing the results of the MAiLgS programme input in terms of the frequency and nature of the MAiLgS. The third process involves presenting the results of each participant and exploring them statistically. Together, these processes determine whether the MAiLgS programme had an effect on the subtraction word-problem solving skills of children with intellectual disabilities.

5.2 Terms

The following terms are used to explain the results of the intervention used in this study:

Frequency of MAiLgS: the number of times that a spoken word is said while simultaneously pointing to the corresponding PCS symbols. According to Goossens' (2000) the frequency of MAiLgS needs to occur for 80% of the words used to teach subtraction word-problems.

Nature of MAiLgS: the ratio between the statements and questions used during the teaching of subtraction word problems. Goossens' (2000) set the ratio of statement: question as 80:20.

Median: middle value of a data-series, ordered from lowest to highest. It was used to calculate levels and trends to limit the effect of outliers on the data (Gast & Spriggs, 2010).

Level: the median score for data points within a phase (Gast & Spriggs, 2010; Horner et al., 2012). The relative level change is used to describe the amount of change in the level within a phase. It is calculated by finding the difference between the median values of the first and second halves of the phase (Gast & Spriggs, 2010). A 20% change to reflect effect for level suggested for smaller samples was used (Gast & Spriggs, 2010).

Trend: the slope of the best-fitting straight line for the outcome measures (data points) within a phase (Kratochwill et al., 2013). The trend line is calculated using the split-middle method of White and Haring (cited in Gast & Spriggs, 2010) whereby the medians for the first and second halves of a phase are calculated and the line drawn between these medians is the trend (Gast & Spriggs, 2010). A trend line is described as zero celerating where the "data points are parallel to the abscissa" (Gast & Spriggs, 2010), accelerating where the data points increase in value across the phase (Gast & Spriggs, 2010) or decelerating where the value of data points decreases across the phase (Gast & Spriggs, 2010). A 20% change to reflect effect for trend suggested for smaller samples was used (Gast & Spriggs, 2010).

Stability: is determined for the level and trend of data points. It is calculated using stability envelopes, whereby 80% of the data points fall within the stability envelope around the level or trend lines (Gast & Spriggs, 2010).

Variability: the standard deviation or range of data points about the best-fitting line (Kratochwill et al., 2013). Variability is calculated using stability envelopes, whereby 80% of the data points fall outside the level or trend line stability envelopes (Gast & Spriggs, 2010).

Percentage of nonoverlapping data (PND): a measure to evaluate outcomes of single-subject research. It determines the proportion of treatment data points that exceeds the highest baseline value (Scruggs & Mastropieri, 2010). PND scores above 90% represent very effective intervention, 70% – 90% represents effective intervention scores, scores between 50% and 70% are questionable and scores below 50% are deemed to be ineffective (Scruggs & Mastropieri, 2001).

Improvement Rate Difference (IRD): the difference in successful performance between baseline and intervention phases (Parker et al., 2009). An IRD of more than 70% is deemed to be large while 50% – 70% is regarded as moderate (Parker et al., 2009).

Omnibus IRD: the average of the full design IRDs (Parker et al., 2009). Confidence intervals (CI) are calculated at 90% and give an indication of the confidence one has in an obtained IRD. Wide CIs indicate that the IRD is not trustworthy (Parker et al., 2009).

5.3 Procedural integrity

Procedural integrity refers to the “degree to which the independent variable is implemented as intended” (Schlosser, 2002, p. 36). This is imperative to ensure not only that the intervention is implemented properly but also in “sufficient dosage levels” (Kratochwill et al., 2013). Procedural integrity was calculated for the general procedures and results reported in Chapter 3.

5.3.1 Procedural integrity of general procedures

The general procedure implementation was measured for the probe tests using the Procedural integrity checklist for probe sessions (Appendix W). The procedures for the probe tests included consideration of the venue preparation, introduction of the mathematical word-problem solving, presentation of the word-problems and closing. Each step was scored as "done" or "omitted". The scores (out of a possible 16) were added and converted to a percentage. Table 5.1 provides the procedural integrity scores of the general procedures for the probe sessions.

Table 5.1 Procedural integrity scores of general procedures used in the probe sessions

Phase	**Initial Baseline**			**Intervention**															**Maintenance**		
Session	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Word-problems	Change, combine and compare word-problem types																				
Raw Score	16/16	16/16	14/16	15/16	15/16	14/16	13/16	14/16	15/16	13/16	15/16	13/16	14/16	12/16	13/16	13/16	12/16	13/16	15/16	15/16	16/16
Percentage	100	100	88	94	94	88	81	88	94	81	94	81	88	75	81	81	75	81	94	94	100
Mean percentage of procedural integrity for all baseline scores: 88.2%																					

The procedural integrity for the probe tests varies from 12 out of 16 (75%) to 16 out of 16 (100%) across the 21 sessions. Overall procedural integrity scores at 88.2%, which is higher than the 80% score deemed acceptable (Ayres & Gast, 2010), indicating that the general procedures were executed accurately across the probe tests.

The general procedure implementation was also measured for the intervention-phase sessions using the Procedural integrity checklist: intervention sessions (Appendix X). The procedures for the intervention sessions included consideration of the venue preparation, greeting, introduction of the mathematical word-problem solving, presentation of the word-problems, application of AiLgS principles (Goossens', 1989) and closing. Each step was scored as "done" or "omitted". The scores (out of a possible 24) were added and converted to a percentage. Table 5.2 provides the procedural integrity scores of the general procedures for the intervention phase sessions.

Table 5.2 Procedural integrity scores of general procedures used in the intervention phase sessions

Phase	Intervention														
Session	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Word-problems	Change, combine and compare word-problem types														
Raw Score	24/24	21/24	22/24	23/24	23/24	24/24	23/24	22/24	22/24	23/24	21/24	22/24	24/24	21/24	23/24
Percentage	100	88	92	96	96	100	96	92	92	96	88	92	100	88	96
Mean percentage of procedural integrity for all intervention sessions: 94.1%															

The procedural integrity for general procedures of the intervention sessions varies from 21 out of 24 (88%) to 24 out of 24 (100%) across the 15 intervention phase sessions. Overall procedural integrity scores at 94.1%, which is higher than the 80% score deemed acceptable (Ayres & Gast, 2010), indicating that the general procedures were executed accurately across the intervention phase sessions.

5.3.2 Procedural integrity of script use

The probe script checklists (Appendix Y) were used to ensure that each word-problem was presented in exactly the same way during each probe test in accordance with the probe script (Appendix N). The probe script checklists were completed by the researcher after each probe test while viewing the video recordings. Completion of these probe script checklists entailed the researcher scoring each word-problem in terms of i) being read to participants, ii) whether words were omitted or iii) whether words were added. The scores were then added and a percentage calculated. Table 5.3 provides the procedural integrity scores of the probe script use for the probe sessions.

Table 5.3 Procedural integrity scores of the probe test scripts used in the probe sessions

Phase	Baseline			Intervention															Maintenance		
Session	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Word-problems	Change, combine and compare word-problem types																				
Raw Score	36/36	36/36	36/36	35/36	36/36	36/36	36/36	36/36	36/36	36/36	36/36	35/36	36/36	36/36	36/36	36/36	36/36	36/36	36/36	36/36	36/36
Percentage	100	100	100	97	100	100	100	100	100	100	100	97	100	100	100	100	100	100	100	100	100
Mean percentage of procedural integrity for all baseline sessions: 99.7%																					

The procedural integrity for the probe script use reveals two scores, namely 35 out of 36 (97%) and 36 out of 36 (100%) in the 21 sessions. Overall procedural integrity for the probe test script use scores at 99.7%, which is considerably higher than the 80% score deemed acceptable (Ayres & Gast, 2010), indicating that the probe scripts were used with great accuracy.

The MAiLgS programme script checklists (Appendices Z, AA & AB) were used to ensure that the script for each word-problem type was followed in the same way during each intervention session. The MAiLgS programme script checklists were completed by the researcher after each intervention session by viewing the intervention video recordings. Table 5.4 provides the procedural integrity scores of the MAiLgS programme script use for the intervention sessions.

Table 5.4 Procedural integrity scores of the MAiLgS programme script used for the intervention sessions

Phase	**Intervention**														
Sessions	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Word-problems	Change, combine and compare word-problem types														
Raw Score	715/726	618/726	704/726	694/726	704/726	486/498	487/498	484/498	489/498	490/498	602/654	638/654	643/654	653/654	646/654
Percentage	98	85	97	96	97	98	98	97	98	98	92	98	98	99	99
Mean percentage of procedural integrity for all intervention sessions: 96.5%															

The procedural integrity for the MAiLgS programme script use was determined by counting the number of words that were scripted to be pointed to. As a result, the number of words is different for the change, combine and compare word-problem types. Procedural integrity for use of the MAiLgS programme script for the change-type word-problems varies from 85% to 98%. The combine-type word-problem MAiLgS programme script uses procedural integrity scores between 97% and 98% and the procedural integrity for the MAiLgS programme script uses scores between 92% and 99%. The overall procedural integrity for the MAiLgS programme script uses scores at 96.5%, which is higher than the 80% score deemed acceptable (Ayres & Gast, 2010), indicating that the MAiLgS programme scripts were used accurately across the three types of word-problem during the intervention phase.

5.4 Description of MAiLgS

5.4.1 Frequency of MAiLgS

Table 5.5 presents the frequency of MAiLgS for each word-problem type. To calculate the frequency of MAiLgS, the MAiLgS programme scripts were checked by the researcher and then a portion of them, as described in Section 3.9.4, were checked by the inter-rater. When each frequency score relating to MAiLgS implementation during the intervention is considered, it is evident that the stipulated frequency of 80% was adhered to in each of the sessions (Goossens', 1989). The Kruskal-Wallis Test was used to compare the means across the three word-problem types to determine whether there was a significant difference among the three types of subtraction word-problem (Steyn, Smit, Du Toit & Strasheim, 2000).

Table 5.5 Frequency of MAiLgS for the three word-problem types of during the intervention phase

	Change word-problems							**Combine word-problems**							**Compare word-problems**							**Kruskal-Wallis Test***
	Session number					**Mean**	**SD**	**Session number**					**Mean**	**SD**	**Session number**					**Mean**	**SD**	
	4	**5**	**6**	**7**	**8**			**9**	**10**	**11**	**12**	**13**			**14**	**15**	**16**	**17**	**18**			
Frequency	98.1%	84%	97%	95%	97.2%	94.26	5.486	98%	97.8%	97%	98.7%	99%	98.10	0.787	92%	97%	98%	99.8%	98.6%	97.08	3.015	p=3.02

* p<0,05

From Table 5.5 it is evident that there was not a statistically significant difference between the three word-problem types (p = 3.02), indicating that the MAiLgS programme was implemented consistently across all three.

5.4.2 Nature of MAiLgS

The MAiLgS programme scripts were checked by the researcher and a portion of them, as explained in Section 3.9.5, was checked by the inter-rater to determine the nature of MAiLgS during the intervention phase. The highest nature of MAiLgS rating (92:8) was achieved for the change and compare word-problems. The combine word-problems scored lowest with regard to the nature of MAiLgS at 84:16. Therefore, the stipulated 80:20 statement: question ratio (Goossens', 1989) was met for all three types of subtraction word-problem. The nature of MAiLgS is presented in Table 5.6 for each intervention session.

Table 5.6 Nature of MAiLgS for the three word-problem types during the intervention phase

	Change word-problems					Combine word-problems					Compare word-problems				
	Session number					Session number					Session number				
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Nature of MAiLgS	92:8	92:8	92:8	92:8	92:8	84:16	84:16	84:16	84:16	84:16	91:9	92:8	92:8	92:8	92:8

5.5 Data integrity

5.5.1 Probe test data

All of the probe answer sheets from the baseline, intervention and maintenance phases were scored by the researcher. The inter-rater then also checked all (100%) of the probe answer sheets, as described in Section 3.9.1.2.

5.6 Effect of intervention on the subtraction word-problem solving abilities of children with intellectual disabilities

This section presents a description of each participant's performance across the three types of subtraction word-problem solving. This is based on the graphic representation of the probe results across the four phases for the change and combine word-problem types and three phases for the compare word-problem type for each participant. Visual analysis of the graphs was done (Campbell & Herzinger, 2010; Gast & Spriggs, 2010; Horner et al., 2012; Kratochwill et al., 2010, 2013) followed by statistical analysis.

5.6.1 Visual analysis of graphs

5.6.1.1 Participant 1

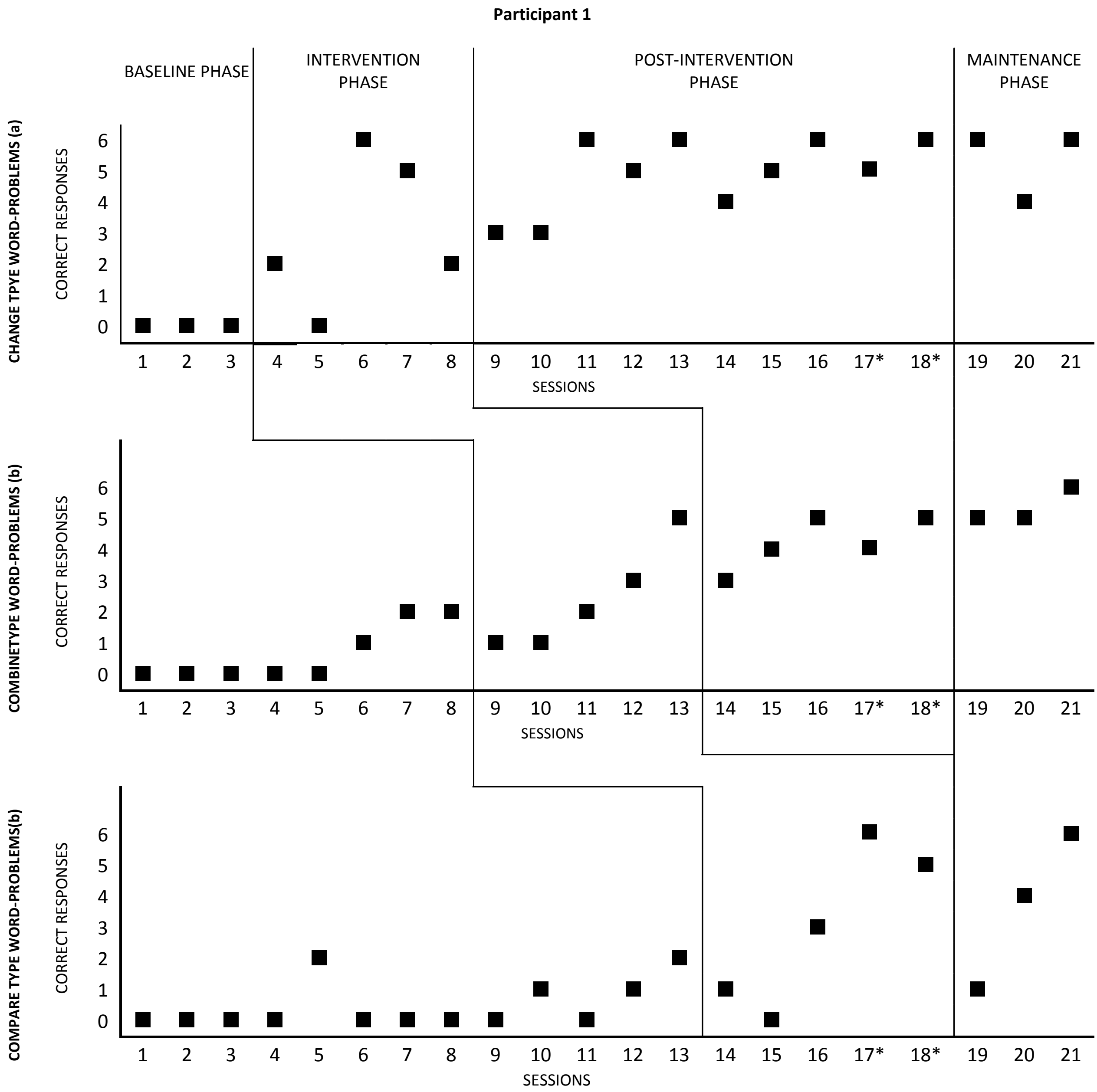

Figure 5.1. Number of correct responses achieved by Participant 1 across three types of subtraction word-problems

Figure 5.1 represents Participant 1's performance during the probe sessions across the three types of subtraction word-problem taught for three weeks. A consistent pattern is observed for Participant 1. During the baseline phases a stable baseline is noted for each type of word-problem and this pattern continues even when the new word-problem type is introduced. With further exposure to the word-problems, Participant 1's performance continued to improve through the intervention and post intervention phases. After the four-week withdrawal period, Participant 1 was able to maintain her word-problem solving scores, indicating that she had maintained the skill after intervention ceased. Consequently, overall performance in the intervention phase for the change word-problems improved from the baseline phase. Participant 1's overall performance for the combine-type word-problems similarly improved from the baseline phase to the intervention phase. Her overall performance for compare-type word-problems improved from the baseline phase into the intervention phase. Omnibus IRD across the three word-problem types was 60%, indicating a moderate improvement (Parker et al., 2009).

In Figure 5.1(a) a stable baseline of 0 is indicated. Levels of the baseline, intervention, post-intervention and maintenance phases were 0, 2, 5 and 6 respectively. In the intervention phase the level was variable, since four of the data points fell outside 20% of the median level. The post-intervention phase level was stable given that eight data points fell within 20% of the median level, and the maintenance phase was also stable with two of the data points falling within 20% of the median level. Level changes of +2, +3 and +1 across the four phases were indicated.

For Figure 5.1(a) the trend sizes as determined by the relative change were 0, +1.5, 0 and 0 for the baseline, intervention, post-intervention and maintenance phases respectively. Accordingly, zero celerating trends were reflected in the baseline, post-intervention and maintenance phases. The intervention phase, however, showed an accelerating trend. The trend of the baseline was stable, with each of the three data points falling within 20% of the trend line. The intervention phase trend was variable, with four of the data points falling 20% outside the trend line. In the post-intervention phase, the trend was stable as eight data points fell within 20% of the trend line. The maintenance phase was similarly stable since two of the data points fell within 20% of the trend line.

The PND when comparing the baseline and intervention phases was 80%, which indicates that the intervention was effective (Scruggs & Mastropieri, 2001). The IRD was 80% and CI at 90% was [17%, 96%], indicative of a large improvement (Parker et al., 2009).

In the combine-type word-problems as illustrated in Figure 5.1(b), Participant 1 achieved a level score of 0 although her scores improved slightly in the last three baseline probe tests. Given the group format used for this study, further data points could not be accommodated for Participant 1.

Levels of the four phases of the combine-type word-problems were 0, 2, 4 and 5 respectively. The baseline phase level was variable as seven of the data points fell 20% outside the median level. In the intervention phase the level was also variable since three of the data points fell outside 20% of the median level. The post-intervention phase level was, however, stable, given that all five data points fell within 20% of the median level, and the maintenance phase also presented as stable with each of the three data points falling within 20% of the median level. A level change between the four phases of +2, +2 and +1 was evident.

In Figure 5.1(b) the trend sizes were +1.5, +3, +1 and +1for the baseline, intervention, post-intervention and maintenance phases. As a result, each phase revealed an accelerating trend. The trend of the baseline was variable with seven data points falling 20% outside the trend line. However the intervention phase trend was stable, with four of the data points falling within 20% of the trend line. In the post-intervention phase the trend was similarly stable with five data points falling within 20% of the trend line. The maintenance phase was also stable as all three data points fell within 20% of the trend line.

The PND between the baseline and intervention phases was 40%, signifying that the intervention was ineffective for the combine-type word-problems (Scruggs & Mastropieri, 2001). The IRD was 40% and 90% CI was [6%, 73%], also suggestive of no effect (Parker et al., 2009).

The compare-type word-problem scores reflected in Figure 5.1(c) reveal that Participant 1 achieved a level of 0 in the baseline phase. Given the group format used for this study, further data points could not be accommodated for Participant 1.

Levels of the baseline, intervention and maintenance phases (no post-intervention phase was done) in the compare-type word-problems were 0, 3, and 4. The level within the baseline phase was variable with 11 of the data points falling 20% outside the median level. In the intervention phase the level was also variable, since three of the data points fell outside 20% of the median level. The maintenance phase level was nonetheless stable as all three data points fell within 20% of the median level. A level change of +3 and +1 between the three phases was indicated.

For Figure 5.1(c) the trend sizes were 0.5, +5 and +5 for the baseline, intervention and maintenance phases. Accordingly, accelerating trends were observed in each of these three phases. The trend of the baseline was variable with 11 data points falling 20% outside the trend line. The intervention phase trend was also variable, with three of the data points falling 20% outside the trend line. The maintenance phase was, however, stable, where each of the three data points fell within 20% of the trend line.

The PND for the baseline and intervention phases was 60%, suggestive of possible effect brought about by the intervention (Scruggs & Mastropieri, 2001). The IRD was 60% and 90% CI was [27%, 86%], which suggests moderate effect (Parker et al., 2009).

5.6.1.2 Participant 2

Figure 5.2 represents Participant 2's performance during the probe sessions across the three types of subtraction word-problems taught for three weeks. The pattern observed for Participant 2 is consistent. Stable baselines are evident for each type of word-problem, with this pattern continuing when the new word-problem type is introduced. Continued exposure to the word-problems resulted in Participant 2's scores continuing to improve through the intervention and post-intervention phases. After the four-week withdrawal period, Participant 2 maintained his word-problem solving scores, suggesting that he had maintained the skill after intervention ceased. Overall performance for the change word-problems improved from the baseline phase into the intervention phase. Participant 2's overall performance for the combine-type word-problems improved slightly, from the baseline phase into the intervention phase. The overall performance score for compare-type word-problems reflected the most improvement from the baseline into the intervention phase. Omnibus IRD across the three word-problem types was 80%, indicating a large improvement (Parker et al., 2009).

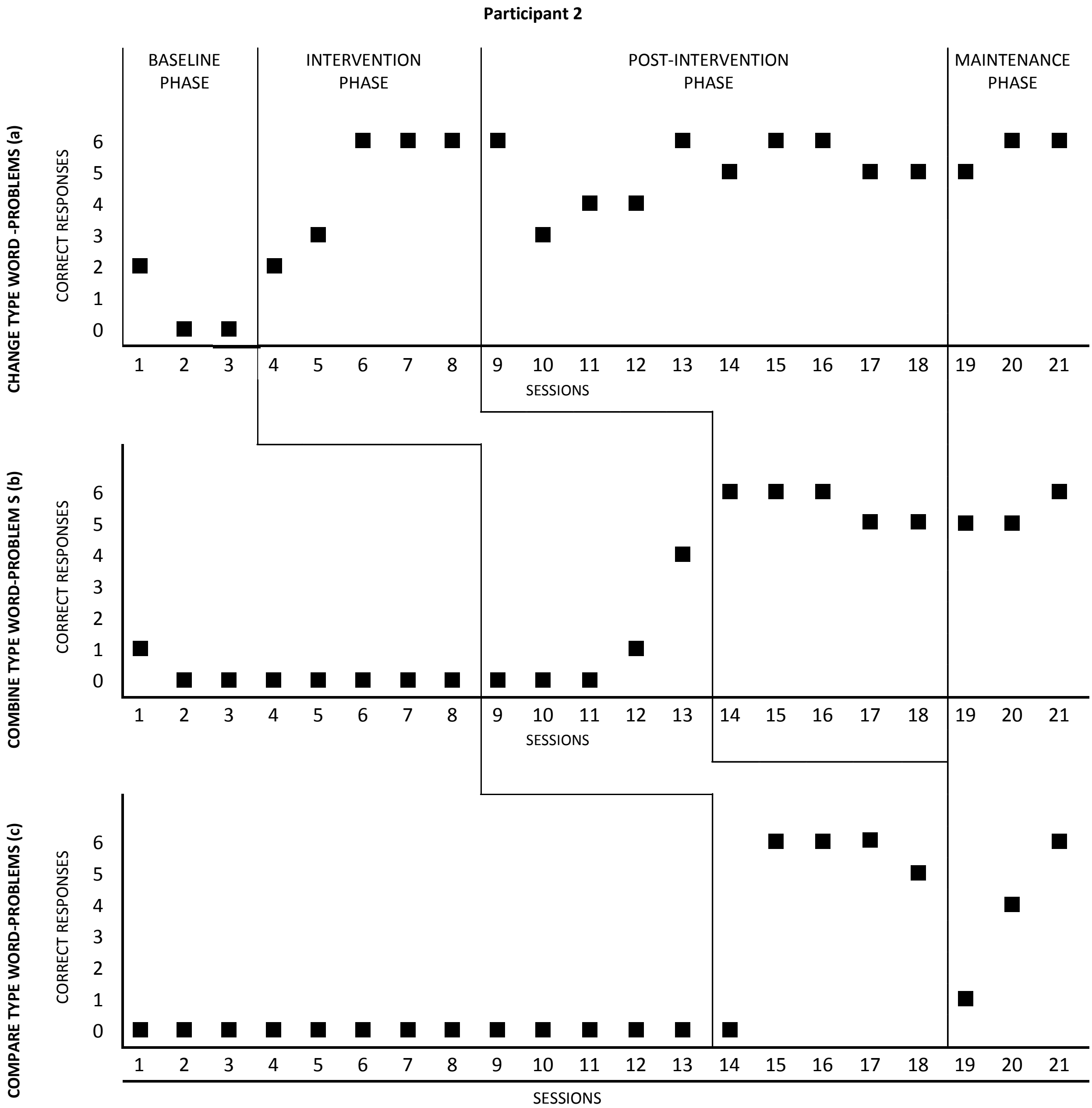

Figure 5.2. Number of correct responses achieved by Participant 2 across three types of subtraction word-problems

In Figure 5.2(a) the baseline was variable, although further data points could not be added for Participant 2 due to the small-group format used. Levels of the baseline, intervention, post-intervention and maintenance phases were 0, 6, 5 and 6 respectively. In the intervention phase the level was variable, since two of the data points fell outside 20% of the median level. The post-intervention phase level was, however, stable with nine data points falling within 20% of the median level, and the maintenance phase was also stable with all three data points falling within 20% of the median level. Level changes of +6, -1 and +1 across the four phases were indicated.

For Figure 5.2(a) the trend sizes as determined by the relative change were -2, +3.5, +2 and +1 for the baseline, intervention, post-intervention and maintenance phases respectively. It is consequently evident that accelerating trends were observed in the intervention, post-intervention and maintenance phases, with only the baseline phase reflecting a decelerating trend. The trend of the baseline was stable as all three data points fell within 20% of the trend line. The intervention phase trend was also stable since four of the data points fell within 20% of the trend line. In the post-intervention phase, the trend was variable as four data points fell 80% outside the trend line. The maintenance phase was stable since all three of the data points fell within 20% of the trend line.

The PND when comparing the baseline and intervention phases was 80%, which indicates that the intervention was effective (Scruggs & Mastropieri, 2001). The IRD was 80% with 90% CI being [17%, 96%], indicating a large improvement (Parker et al., 2009).

In the combine-type word-problems that are illustrated in Figure 5.2(b), Participant 2 achieved level scores of 0, 0, 6 and 5 for the four phases of the combine-type word-problems respectively. The baseline phase level was variable due to one of the data points falling 20% outside the median level. In the intervention phase the level was similarly variable, with two of the data points falling 20% outside the median level. The post-intervention phase level was, however, stable given that eight data points fell within 20% of the median level, and the maintenance phase also presented as stable with each of the three data points falling within 20% of the median level. A level change between the four phases of +6, -1 and +1 was noted.

In Figure 5.2(b) the trend sizes were 0, +2.5, -1 and +1 for the four phases. Accelerating trends were observed in the intervention and maintenance phases while the baseline phase showed zero celeration and the post-intervention phase reflected a decelerating trend. Trend stability was observed across the four phases, since seven baseline, four intervention, five post-intervention and three maintenance phase data points fell within 20% of the trend lines in these phases.

The PND between the baseline and intervention phases was 20%, signifying that the intervention was ineffective for the combine-type word-problems (Scruggs & Mastropieri, 2001). The IRD was 80% with 90% CI being [6%, 73%], suggestive of a large effect (Parker et al., 2009).

The compare-type word-problem scores as reflected in Figure 5.2(c) indicate that Participant 2 achieved a level of 0 in the baseline phase. Levels of the baseline, intervention and maintenance phases (no post-intervention phase was done) in the compare-type word-problems were 0, 6, and 4. The level within the baseline phase was stable with all 13 data points falling within 20% of the median level. In the intervention phase the level was variable because four of the data points fell outside of 20% of the median level. The maintenance phase level was stable as all three data points fell within 20% of the median level. Level changes of +6 and -2 between these three phases were noted.

For Figure 5.2(c) the trend sizes were 0, +2.5 and +5 for the baseline, intervention and maintenance phases. Accordingly, only the baseline phase shows a zero celerating trend. The intervention and maintenance phases, however, reflect accelerating trends. The trend of the baseline was stable with each of the 13 data points falling within 20% of the trend line. The intervention phase trend was, however, variable, as four data points fell 80% outside the trend line. The maintenance phase trend was stable with the three data points falling within 20% of the trend line.

The PND for the baseline and intervention phases was 100%, with the intervention presenting as being very effective (Scruggs & Mastropieri, 2001). The IRD was 80% with 90% CI being [27%, 86%], suggesting a large improvement effect (Parker et al., 2009).

5.6.1.3 Participant 3

Figure 5.3 represents Participant 3's performance during the probe sessions across the three types of subtraction word-problem taught for three weeks. Participant 3's scores were relatively consistent with only one outlier. The baselines for the change and combine-type word-problems were variable although the compare baseline was stable. Minimal movement was observed in Participant 3's scores following introduction of the intervention. This was similarly noted during both the post-intervention and maintenance phases. The highest overall performance occurred for the change word-problems, where an improvement was noted from the baseline phase into the intervention phase. Participant 3's overall performance for the combine-type word-problems deteriorated from the baseline phase score to the intervention phase score. The overall performance score for compare-type word-problems was consistent with Participant 3 scoring 2 correct in both the baseline and intervention phases. Omnibus IRD across the three word-problem types was 15.3%, indicating minimal improvement (Parker et al., 2009).

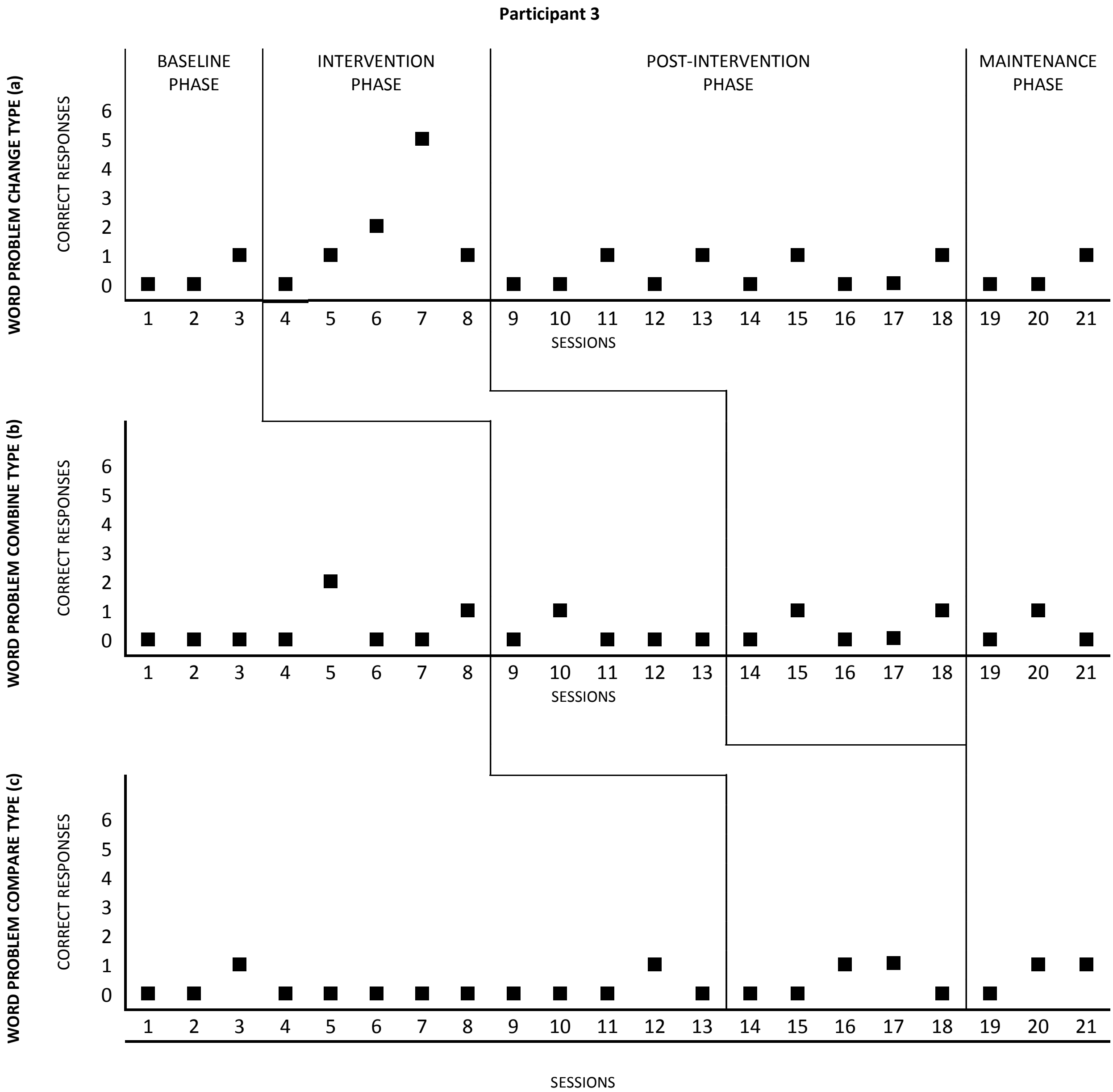

Figure 5.3. Number of correct responses achieved by Participant 3 across three types of subtraction word-problems

In Figure 5.3(a) levels of the baseline, intervention, post-intervention and maintenance phases were 0, 1, 0 and 0 respectively. The baseline was variable, with one data point falling 20% outside the level. Further data points could not be added for Participant 3 due to the small-group format used. The intervention and post-intervention phases were similarly variable, with three and four data points falling outside 20% of the median levels of these phases respectively. Level changes of +1, -1 and 0 across the four phases were indicated. For Figure 5.3(a) the trend sizes as determined by the relative change were +1, +3, 0 and +1 for the baseline, intervention, post-intervention and maintenance phases respectively. Accelerating trends were thus observed in the baseline, intervention and maintenance phases while zero celeration was observed during the post-intervention phase. The trends of the four phases were all variable given that one baseline, two intervention, four post-intervention and one maintenance phase data points fell 80% outside the trend line.

The PND when comparing the baseline and intervention phases was 40%, which indicates that the intervention was ineffective (Scruggs & Mastropieri, 2001). The IRD was 46% with 90% CI being [-14%, 83%], indicating minimal improvement (Parker et al., 2009).

For the combine-type word-problems illustrated in Figure 5.3(b), Participant 3's level scores for the four phases were all 0. The baseline phase level was variable due to two data points not being within 20% of the median level. In the intervention phase the level was, however, stable with only one data point falling 20% outside the median level. The post-intervention phase level was variable given that two data points did not fall within 20% of the median level, and the maintenance phase also presented as variable with one of the three data points not falling within 20% of the median level. No level changes between the four phases were noted.

The trend sizes for the combine-type word-problems as depicted by Figure 5.3(b) were +0.5, -0.5, +0.5 and 0 across the four phases. The baseline phase was the only phase to show an accelerating trend. Both the intervention and post-intervention phases presented with decelerating trends and zero celeration was observed during the maintenance phase. Trend variability was observed across the four phases, with four baseline, two intervention, all five post-intervention and one maintenance phase data points falling 80% outside the trend lines of these phases.

The PND between the baseline and intervention phases was 0%, signifying that the intervention was ineffective for the combine-type word-problems (Scruggs & Mastropieri, 2001). The IRD was also 0% with 90% CI being [-27%, 37%], suggestive of no improvement (Parker et al., 2009).

The compare-type word-problem scores reflected in Figure 5.3(c) show that Participant 3 achieved a level of 0 in the baseline phase. Levels of the intervention and maintenance phases (no post-intervention phase was done) in the compare-type word-problems were 0 and 1. The level within the baseline phase was stable, with 11 data points falling within 20% of the median level. In the intervention phase the level was variable since two data points fell outside 20% of the median level. The maintenance phase level was also variable with one data point falling 80% outside the median level. There was no level change between the baseline and intervention phase and only a +1 level change from the intervention to maintenance phase.

For Figure 5.3(c) the trend sizes were 0, +0.5 and +1 for the baseline, intervention and maintenance phases. The baseline phase thus shows a zero celerating trend while the intervention and maintenance phases reflect gently accelerating trends. The trend of the baseline was stable with 11 data points falling within 20% of the trend line. The intervention phase trend was variable, since three data points fell 80% outside the trend line. The maintenance phase trend was variable too, with two data points falling 80% outside the trend line.

The PND for the baseline and intervention phases was 0%, indicating that the intervention was ineffective (Scruggs & Mastropieri, 2001). The IRD was 0% with 90% CI being [-18%, 36%], suggesting no improvement effect (Parker et al., 2009).

5.6.1.4 Participant 4

Figure 5.4 represents Participant 4's performance during the probe sessions across the three types of subtraction word-problem taught for three weeks. The pattern observed for Participant 4 is similar across the three types of word-problem. Although only the baseline for the compare-type word-problems is observed, intervention for the change and combine types of word-problem was initiated due to the small-group format used. Following introduction of the intervention, Participant 4's performance was consistently low in the first two intervention phase sessions, only to improve and stabilise over the last three sessions. Participant 4 maintained his word-problem solving ability during the post-intervention and maintenance phases. Participant 4's overall performance scored highest for the change word-problems, with his baseline phase score increasing considerably in the intervention phase. His overall performance for the combine-type word-problems improved slightly from the baseline phase to the intervention phase. The overall performance score for compare-type word-problems also improved from the baseline phase to the intervention phase. Omnibus IRD across the three word-problem types was 66.7%, indicating moderate improvement (Parker et al., 2009).

In Figure 5.4(a) the baseline level was 0. It was regarded as variable, with one data point falling 80% outside the median level. The levels of the intervention, post-intervention and maintenance phases were 5, 6 and 6 respectively. Level stability was observed across the

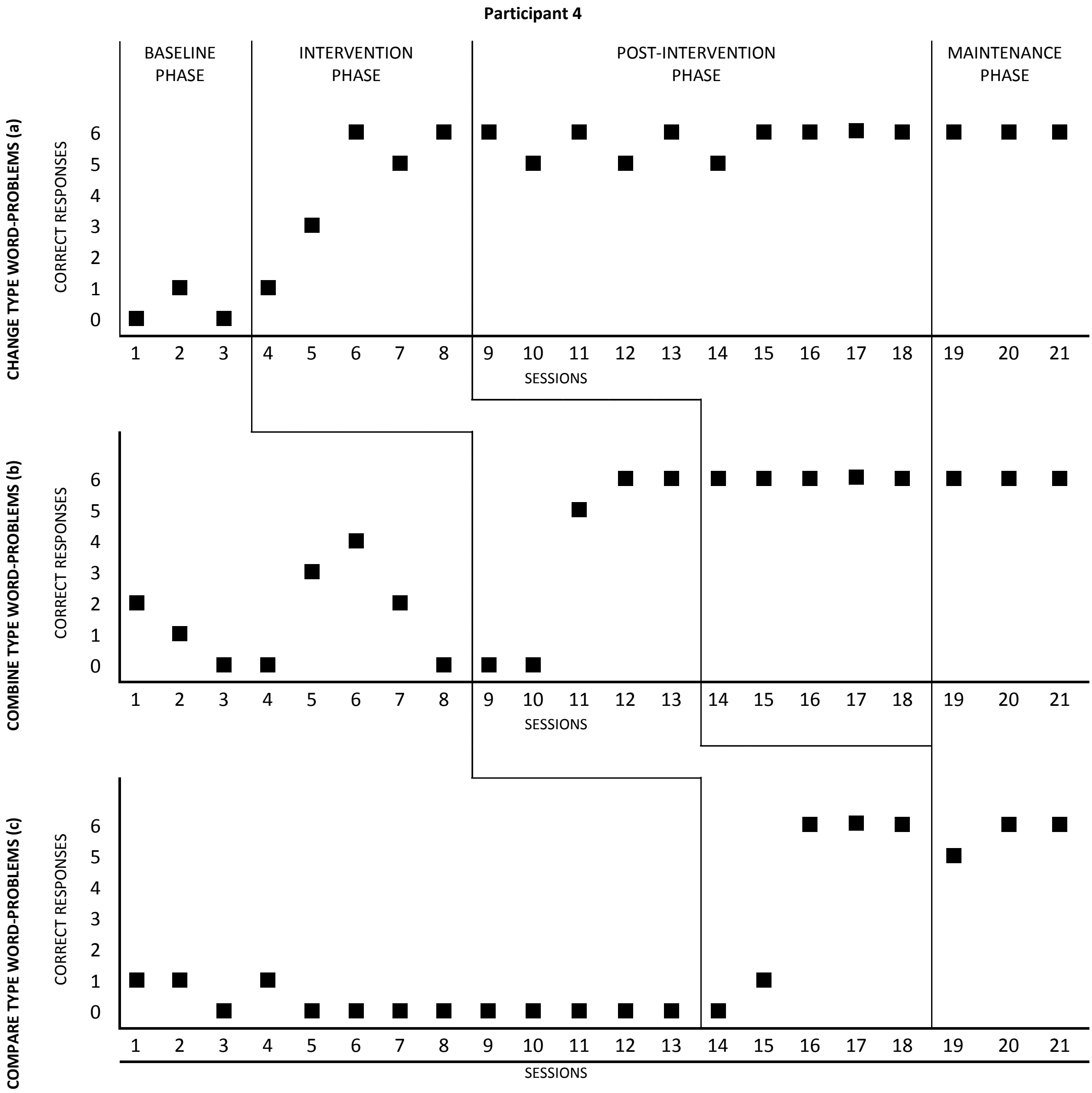

Figure 5.4. Number of correct responses achieved by Participant 4 across three types of subtraction word-problems

intervention, post-intervention and maintenance phases since 80% of the data points in these phases fell within 20% of the median levels. Level changes of +5, -1 and 0 across the four phases were indicated.

For Figure 5.4(a) the trend sizes as determined by the relative change for the baseline, intervention, post-intervention and maintenance phases were 0, +3.5, 0 and 0 respectively. It was consequently evident that zero celerating trends were observed in the baseline, post-intervention and maintenance phases, with only the intervention phase reflecting an accelerating trend. The trend of the baseline was variable as one data point fell 80% outside the trend line. The intervention phase trend was also variable since four of the data points fell 80% outside the trend line. Both the post-intervention and maintenance phases had stable trends where all of the data points were within 20% of the trend line.

The PND when comparing the baseline and intervention phases was 80%, which indicates that the intervention was effective (Scruggs & Mastropieri, 2001). The IRD was 80% with 90% CI being [17%, 96%], indicating large improvement (Parker et al., 2009).

In the combine-type word-problems illustrated in Figure 5.4(b), Participant 4 achieved increasing level scores of 1.5, 5, 6 and 6 for the four phases of the combine-type word-problems respectively. Positive level changes between the four phases of +3.5, +1 and +1 were consequently apparent. The baseline phase level was variable since seven of the data points fell 80% outside the median level. In the intervention phase the level was similarly variable with two of the data points falling 80% outside the median level. The post-intervention and maintenance phase levels were, however, stable given that each data point of these phases fell within 20% of the median levels.

In Figure 5.4(b) the trend sizes were +2, +6, 0 and 0 for the four phases. Accelerating trends were observed in the baseline and intervention phases, with that of the intervention phases accelerating steeply. Zero celeration was shown in the post-intervention and maintenance phases, since Participant 4 achieved perfect scores in them. The baseline and intervention phase were variable as six baseline and three intervention phase data points fell

80% outside the trend lines. Conversely, trend stability was observed during the post-intervention and maintenance phases where all of the data points fell within 20% of the trend lines in these phases.

The PND between the baseline and intervention phases was 60%, signifying questionable effect during intervention for the combine-type word-problems (Scruggs & Mastropieri, 2001). The IRD was 60% with 90% CI being [24, 86%], suggestive of moderate improvement (Parker et al., 2009).

The compare-type word-problem scores that are reflected in Figure 5.4(c) show that Participant 4 achieved a level of 0 in the baseline phase. Levels of 6 in the intervention and maintenance phases (no post-intervention phase was done) of the compare-type word-problems were observed. There were level changes of +6 and 0 between the baseline, intervention and maintenance phases. Level variability was found in the baseline and intervention phases, given that most were 80% outside the level stability envelopes. Only the maintenance phase showed level stability, with all three data points falling within 20% of the median level.

In Figure 5.4(c) the trend sizes were 0, +5.5 and +1 for the baseline, intervention and maintenance phases. A zero celerating trend was shown in the baseline phase. A steeply accelerating trend was noted in the intervention phase while a gently accelerating trend was evident in the maintenance phase. The trend of the baseline was variable with three data points falling 80% outside the trend line. The intervention phase trend was also variable since two data points fell 80% outside the trend line. The maintenance phase trend was stable though, with all three data points falling within 20% of the trend line.

The PND for the baseline and intervention phases was 60%, suggesting questionable intervention effect (Scruggs & Mastropieri, 2001). The IRD was 60% with 90% CI being [27%, 86%], suggesting moderate improvement (Parker et al., 2009).

5.6.1.5 Participant 5

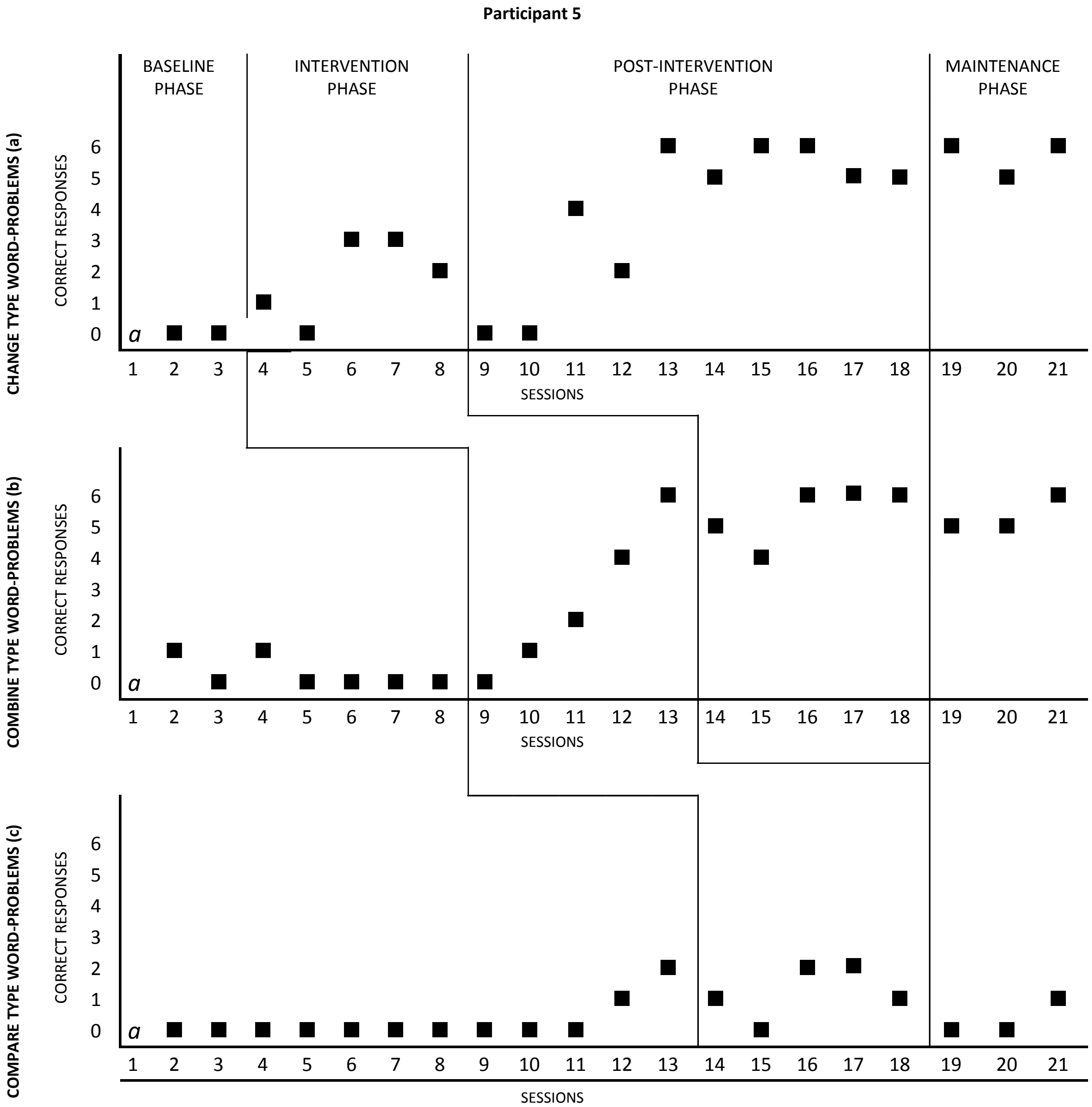

Figure 5.5. Number of correct responses achieved by Participant 5 across three types of subtraction word-problems

Figure 5.5 portrays Participant 5's performance during the probe sessions across the three types of subtraction word-problem taught for three weeks. Consistent patterns are observed for Participant 5 in the change and combine-type word-problems. For these types of word-problem, Participant 5 demonstrated improved ability to solve the word-problems after being introduced to the intervention. Her ability to solve the word-problems continued into the post-intervention and maintenance phases. In the compare-type word-problems, however, Participant 5 showed some improvement in her ability to solve the word-problems, although this improvement was not as clear as for the other types of word-problem. Participant 5's overall performance in the intervention phases for the three types of word-problems improved from the baseline phases. Omnibus IRD across the three word-problem types was 67.7%, indicating moderate improvement (Parker et al., 2009).

In Figure 5.5(a) a stable baseline with a level of 0 is indicated. Levels for the intervention, post-intervention and maintenance phases were 2.5, 5 and 6 respectively, showing positive level changes of +2.5, +2.5, +1 across the four phases. The intervention phase level was variable with two data points falling 80% outside the median level. The post-intervention phase level was also variable given that three data points fell 80% outside the median level. The maintenance phase was, however, stable with all three data points falling within 20% of the median level.

From Figure 5.5(a) the trend sizes as determined by relative change were 0, +2, +3, and 0 for the baseline, intervention, post-intervention and maintenance phases respectively. The baseline and maintenance phases both showed zero celerating trends, while accelerating trends were observed for the intervention and post-intervention phases. The trend of the baseline was stable with each data point falling within 20% of the trend line. A stable trend was also evident in the maintenance phase where each of the three data points fell within 20% of the trend line. Variability was apparent in the intervention and post-intervention phases where three intervention and six post-intervention data points were 80% outside the trend lines.

The PND when comparing the baseline and intervention phases was 80%, which indicates intervention effect (Scruggs & Mastropieri, 2001). The IRD was 80% and 90% CI was [6%, 96%], indicative of large improvement (Parker et al., 2009).

In Figure 5.5(b), which portrays the combine-type word-problems, Participant 5 achieved a median level score of 0 in the baseline phase. Her median level in the intervention phase was 2, in the post-intervention phase it was 6 and in the maintenance phase it was 5. Accordingly, the level changes between the four phases were +2, +4 and -1.

The baseline phase level was variable as two of the data points fell 80% outside the median level. The intervention phase level was also variable, with four data points falling 80% outside the median level. The post-intervention phase level was stable since four data points fell within 20% of the median level. The maintenance phase level also presented as stable with all three data points falling within 20% of the median level.

In Figure 5.5(b) the trend sizes were -1, +4.5, +1.5, and +1 for the baseline, intervention, post-intervention and maintenance phases. There was a decelerating trend in the baseline phase, while accelerating trends were observed in the intervention, post-intervention and maintenance phases. The baseline trend was variable, with five data points falling 80% outside the trend line. Trend stability was observed in the intervention, post-intervention and maintenance phases. Four data points fell within 20% of the trend line in the intervention phase, five data points fell within 20% of the trend line in the post-intervention phase and all three of the data points fell within 20% of the trend line in the maintenance phase.

The PND between the baseline and intervention phases was 60%, signifying that the intervention effect was questionable for the combine-type word-problems (Scruggs & Mastropieri, 2001). The IRD was 60% and 90% CI was [20%, 87%], suggestive of moderate improvement (Parker et al., 2009).

The compare-type word-problem scores reflected in Figure 5.5(c) reveal that Participant 5 achieved a median level of 0 in the baseline phase. Her median levels for the intervention and maintenance phases (no post-intervention phase was done) in the compare-type word-problems were 1 and 0. As a result, the level changes across the three phases were +1 and -1. The baseline level showed stability with 80% of the data points falling within 20% of the median level. There was variability within the intervention phase, since three data points fell 80% outside the median level. The maintenance phase level was also variable as one data point fell 80% outside the median level.

In terms of the trend sizes for Figure 5.5(c), the baseline trend size was 0 while the intervention and maintenance phase trend sizes were both +1. Zero celerating trends were observed in both the baseline and maintenance phases, while a gentle accelerating trend was observed for the intervention phase. Variability around the trend lines in each of the phases was evident with two baseline phase data points, three intervention phase data points and one maintenance phase data points falling 80% outside the trend lines.

The PND for the baseline and intervention phases was 0%, suggestive of no effect being brought about by the intervention (Scruggs & Mastropieri, 2001). The IRD was 63% and 90% CI was [20%, 86%], which suggests moderate effect (Parker et al., 2009).

5.6.1.6 Participant 6

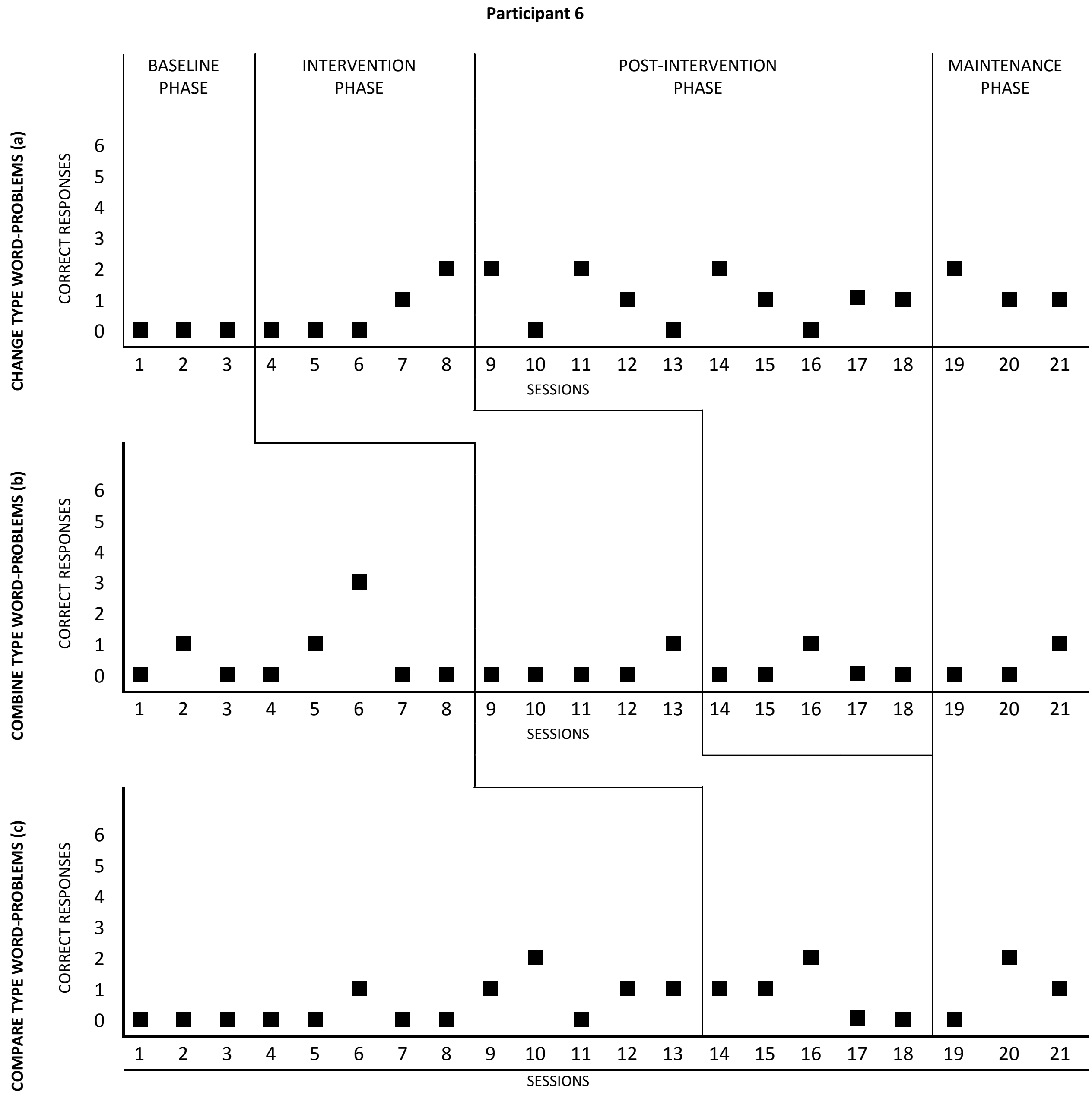

Figure 5.6. Number of correct responses achieved by Participant 6 across three types of subtraction word-problems

Figure 5.6 represents Participant 6's performance during the probe sessions across the three types of subtraction word-problem taught for three weeks. During the baseline phases, Participant 6's scores were variable although the nature of the intervention (small-group format) dictated that intervention be initiated. On introducing the intervention, Participant 6's scores did not show a marked improvement. This pattern continued into the maintenance phase. Her overall performance in the change-type word-problems improved marginally from the baseline to the intervention phase. Her overall performance for the combine- and compare type word-problems, however, deteriorated from the baseline to the intervention phase. Omnibus IRD across the three word-problem types was 13.3%, indicating minimal improvement (Parker et al., 2009).

In Figure 5.6(a) the levels in the baseline, intervention, post-intervention and maintenance phases were 0, 0, 1 and 1 respectively. There were level changes of 0, +1 and 0 across the four phases. The baseline was stable. Variability was observed around the median levels in the intervention, post-intervention and maintenance phases. Two intervention phase data points, six post-intervention phase and one maintenance phase data points all fell 80% outside the median level.

For Figure 5.6(a) the trend sizes as determined by the relative change were 0, +1.5, 0 and -1 for the baseline, intervention, post-intervention and maintenance phases respectively. In the baseline and post-intervention phases zero celerating trends were observed. An accelerating trend was noted in the intervention phase, while the maintenance phase was characterised by a decelerating trend. A stable trend was noted for the baseline phase while the other three phases showed variability, with three intervention phase, six post-intervention phase and one maintenance phase data points falling 80% outside the trend line.

The PND when comparing the baseline and intervention phases was 20%, indicating that the intervention was not effective (Scruggs & Mastropieri, 2001). The IRD was 40% with 90% CI being [-20%, 74%], indicating minimal improvement (Parker et al., 2009).

For the combine-type word-problems, illustrated in Figure 5.6(b), Participant 6's level scores for the four phases were all 0. Level changes of 0, 0, 1 and 1 were observed between the four phases. Variability was noted in the baseline phase with three data points falling 80% outside the median level, as well as in the maintenance phase where one data point fell 80% outside the median level. Stability was, however, observed in the intervention and post-intervention phases, with four data points being 20% within the median levels in each of these phases.

The trend sizes for the combine-type word-problems as shown in Figure 5.3(b) were +0.5, +0.5, 0 and +0.5 across the four phases. Slightly accelerating trends were noted in the baseline, intervention and maintenance phases, while a zero celerating trend was seen in the post-intervention phase. The baseline, intervention and maintenance phases were characterised by variability as seven baseline, three intervention and one maintenance phase data points fell 80% outside the trend line. The post-intervention phase was, however, stable with four data points falling within 20% of the trend line.

The PND between the baseline and intervention phases was 0%, signifying that the intervention was ineffective (Scruggs & Mastropieri, 2001). The IRD was also 0% with 90% CI being [-18%, 36%], suggestive of no improvement (Parker et al., 2009).

The compare-type word-problem scores reflected in Figure 5.6(c) show that Participant 6 achieved a median level of 0 in the baseline phase. In the intervention and maintenance phases the median levels were both 1. As a result, a level change only occurred between the baseline and intervention phases, scoring 1. The baseline phase's level was variable with five data points falling 80% outside the median level. In the intervention phase the level was variable since three data points fell 80% outside the median level. Variability was also noted in the maintenance phase, where two data points fell 80% outside the median level.

For Figure 5.6(c) the trend sizes were +1, -1 and +1 for the baseline, intervention and maintenance phases respectively. The baseline phase shows a slightly accelerating trend which was also noted in the maintenance phase. There was a decelerating trend in the intervention phase. The baseline phase shows a variable trend with eight data points falling 80% outside the trend line. The maintenance phase trend was similarly variable since one data point fell 80% outside the trend line. There was a stable trend reflected in the intervention phase as four data points fell within 20% of the trend line.

The PND for the baseline and intervention phases was 0%, indicating that the intervention was ineffective (Scruggs & Mastropieri, 2001). The IRD was also 0% with 90% CI being [-18%, 36%], suggesting no improvement (Parker et al., 2009).

5.6.1.7 Participant 7

Figure 5.7 represents Participant 7's performance during the probe sessions across the three types of subtraction word-problem taught for three weeks.

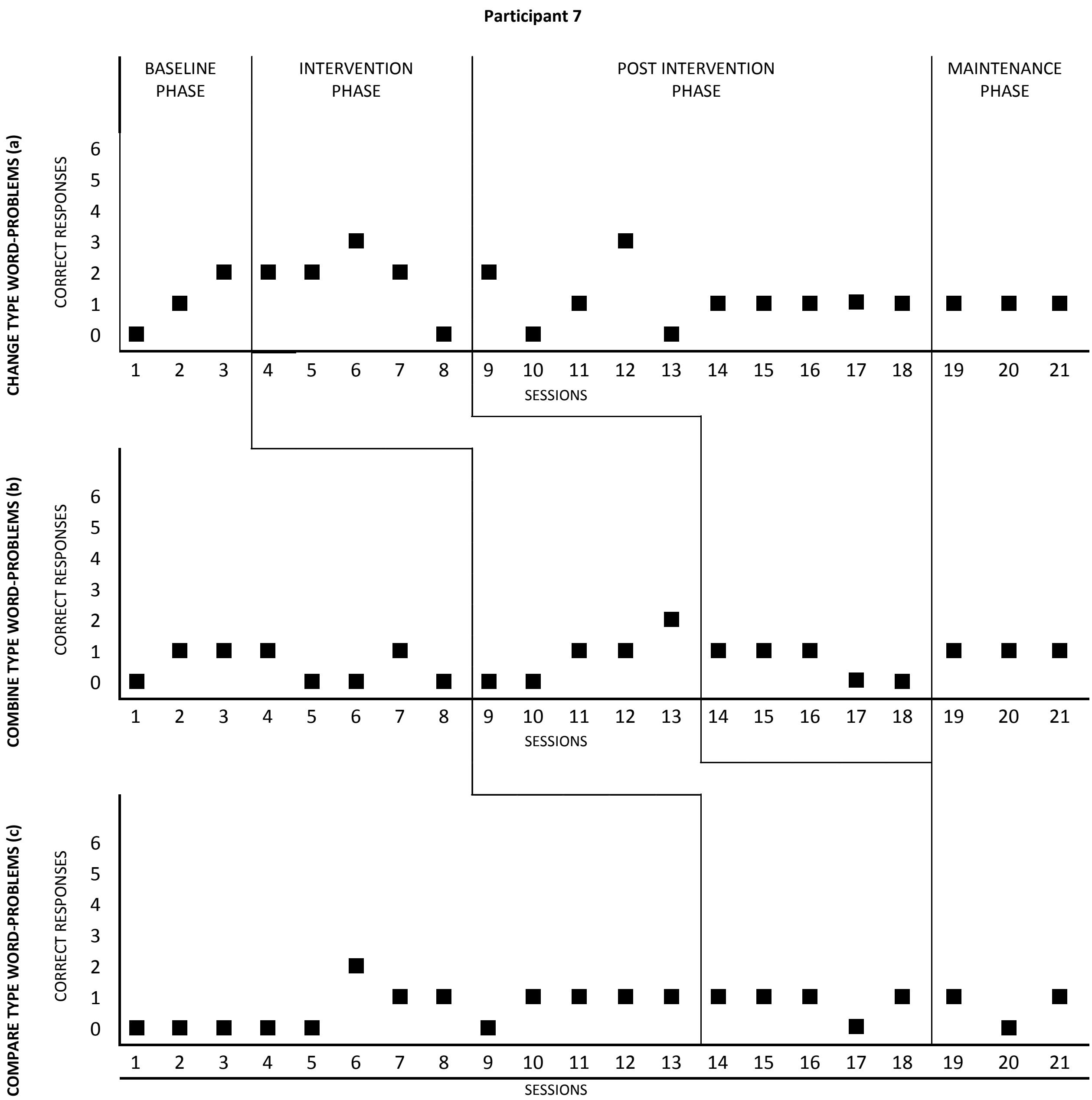

Figure 5.7. Number of correct responses achieved by Participant 7 across three types of subtraction word-problems

Participant 7's performance across the three types of word-problem remained fairly consistent with similar results being seen in each type, even after introduction to the intervention. Variability was observed in the baseline scores for Participant 7 although intervention was started for each type of word-problem due to the small-group format used, which did not allow for additional data points to be added for Participant 7. Overall performance for the change word-problems improved from the baseline to the intervention phase. Participant 7's overall performance for the combine- and compare type word-problems, however, deteriorated from the baseline to the intervention phase. Omnibus IRD across the three word-problem types was 6.7%, indicating negligible improvement (Parker et al., 2009).

In Figure 5.7(a) levels for the baseline, intervention, post-intervention and maintenance phases were 1, 2, 1 and 1 respectively. Level changes of +1, -1 and 0 across the four phases were thus indicated. The baseline level was variable, with two data points falling 80% outside the median level. The intervention phase level was similarly variable with two data points falling 80% outside the median level.

For Figure 5.7(a) the trend sizes as determined by the relative change were +2, -1, -1 and 0 for the baseline, intervention, post-intervention and maintenance phases respectively. An accelerating trend was only observed in the baseline phase. There were decelerating trends in both the intervention and post-intervention phases, while zero celeration was observed in the maintenance phase. The baseline phase trend was stable, with each data point falling within 20% of the trend line. Variability was observed in the intervention phase where three data points fell 80% outside the trend line. Nine data points fell 80% outside the trend line of the post-intervention phase, making it variable. The maintenance phase was stable as three data points fell within 20% of the trend line.

The PND when comparing the baseline and intervention phases was 20%, which indicates that the intervention was ineffective (Scruggs & Mastropieri, 2001). The IRD was 0% with 90% CI being [-38%, 51%]; indicating no improvement following intervention (Parker et al., 2009).

For the combine-type word-problems, as illustrated in Figure 5.7(b), Participant 7's median level for the baseline phase was 0.5. The median level in the intervention, post-intervention and maintenance phases was 1 in each phase. This results in a level change of +0.5, 0 and 0 between the four phases. The baseline phase level was variable with four data points not being within 20% of the median level. In the intervention phase the level was similarly variable, as three data points fell outside the level stability envelope. The post-intervention phase level was also variable given that three data points did not fall within 20% of the median level. The maintenance phase level was, however, stable given that each of the three data points fell within 20% of the median level.

The trend sizes for the combine type word-problems as depicted by Figure 5.7(b) were -1, +1.5, -1 and 0 for the four phases. A slightly accelerating trend was shown in the intervention phase, while the baseline and post-intervention phases were both characterised by decelerating trends. The maintenance phase showed a trend having zero celeration. Trend variability was present in the baseline, intervention and post-intervention phases, with five, two and two data points not falling within 20% of the trend lines in these phases. The trend line in the maintenance phase was, however, stable given that each of the three data points fell within the stability envelopes.

The PND for the combine-type word-problems between the baseline and intervention phases was 20%, signifying that the intervention was ineffective (Scruggs & Mastropieri, 2001). The IRD was also 20% with 90% CI being [-10%, 58%], suggestive of no improvement following intervention (Parker et al., 2009).

The compare-type word-problem scores shown in Figure 5.7(c) demonstrate that Participant 7 achieved a median level of 1 in the baseline phase and this continued through the intervention and maintenance phases (no post-intervention phase was done). Consequently, no level change was observed between the three phases. The level within the baseline phase was variable with seven data points not falling within 20% of the median level. In the intervention phase the level was stable though, since four data points fell within 20% of the median level. The maintenance phase level was also variable with one data point falling 20% outside the median level.

For Figure 5.7(c) the trend sizes were +1.5, -0.5 and 0 for the baseline, intervention and maintenance phases. The baseline phase thus showed a slightly accelerating trend. A decelerating trend was evident in the intervention phase, while the maintenance phase reflected a trend with zero celeration. The baseline trend was variable given that seven data points fell outside the 20% stability envelopes. The intervention phase trend was also variable, due to three data points falling 20% outside the trend line. The maintenance phase trend was similarly variable, with one data point falling 20% outside the trend line.

The PND for the baseline and intervention phases was 0%, indicating that the intervention for compare-type word-problems was ineffective (Scruggs & Mastropieri, 2001). The IRD was also 0% with 90% CI being [-18%, 36%], suggesting no improvement (Parker et al., 2009).

5.6.3 Summary of participant results

Consideration of the participant results in solving three types of subtraction word-problem as measured by the baseline tests revealed varied results across the seven participants (Table 5.7). When the trend for each participant was explored, it was apparent that for Participants 1, 2, 4 and 5, improvement in their results was noted from the baseline to the post-intervention phase. It was further observed that with these four participants, their performance in the maintenance baseline tests was higher than or similar to their post-intervention scores. Participants 3, 6 and 7 did not, however, demonstrate similar trends in their scores and no discernible positive pattern was evident. Of the seven participants, these three also reflected the lowest maintenance scores. It was noted that of the seven participants, Participants 3 and 7 consistently scored 0% for each type of subtraction word-problem with regard to PND, confirming that minimal change was effected during the learning process after the baseline phase.

5.7 Conclusion

The results of the study were presented in this chapter. This was done using three processes. The first process described the procedural integrity of the general procedures used in the probe and intervention sessions as well as for the script used during the probe and implementation of the MAiLgS programme. The second process involved describing the results of the MAiLgS programme input in terms of the frequency and nature of the MAiLgS. Thirdly, the results of each participant were presented and visually analysed. This was followed by statistical analysis of the data. Together, these processes determined that the MAiLgS programme had an effect on the subtraction word-problem solving skills of four children with intellectual disabilities.

Table 5.7 Intervention effect across seven participants

Participants	Word-problem types	Number of baseline test questions answered correctly				PND Score	IRD Score (CI at 90%)	Level change	Trend change	Immediacy of effect
		Baseline	**Intervention**	**Post-intervention**	**Maintenance**					
Participant 1	Change	0/18	15/30	49/60	16/18	80%	80% (17%, 96%)*	+2*	+1.5	+2*
	Combine	5/48	12/30	21/30	16/18	40%	40% (6%, 73%)	+2*	+1.5	-1
	Compare	6/78	15/30	-	11/18	60%	60% (27%, 86%)*	+3*	+4.5*	-1
	Total	**11/144**	**40/90**	**70/90**	**43/54**	-	**60% Omnibus IRD***	-	-	-
Participant 2	Change	2/18	23/30	50/60	17/18	80%	80% (17%, 96%)*	+6*	+5.5*	+3*
	Combine	1/48	5/30	28/30	16/18	20%	80% (42%, 96%)*	0	+2.5*	0
	Compare	0/78	23/30	-	11/18	100%	80% (43%, 96%)*	+6*	+2.5*	+5*
	Total	**3/144**	**51/90**	**78/90**	**44/54**	-	**80% Omnibus IRD***	-	-	-
Participant 3	Change	1/18	9/30	4/60	1/18	40%	46% (14%, 83%)	+1	+2*	+1
	Combine	3/48	1/30	2/30	1/18	0%	0% (27%, 37%)	0	-1	-1
	Compare	2/78	2/30	-	2/18	0%	0% (18%, 36%)	0	+0.5	-1
	Total	**6/144**	**12/90**	**6/90**	**4/54**	-	**15.3% Omnibus IRD**	-	-	-
Participant 4	Change	1/18	27/30	57/60	18/18	80%	80% (17%, 96%)*	+5*	+3.5*	+3*
	Combine	12/48	23/30	30/30	18/18	60%	60% (24%, 86%)*	+4*	+4*	-2
	Compare	3/78	19/30	-	17/18	60%	60% (27%, 86%)*	+6*	+5.5*	+1
	Total	**16/144**	**69/90**	**87/90**	**53/54**	-	**66.7% Omnibus IRD***	-	-	-
Participant 5	Change	0/15	12/30	27/60	17/18	80%	80% (6%, 96%)*	+2.5*	+3*	+1
	Combine	2/42	13/30	27/30	16/18	60%	60% (20%, 87%)*	+2*	+5.5*	+1
	Compare	3/72	5/30	-	1/18	0%	63% (20%, 86%)	+1	+1	0
	Total	**5/129**	**30/90**	**54/90**	**34/54**	-	**67.7% Omnibus IRD***	-	-	-
Participant 6	Change	0/18	3/30	8/60	4/18	40%	40% (-20%, 74%)	0	+1.5	0
	Combine	5/48	1/30	1/30	1/18	0%	0% (-27%, 37%)	0	0	0
	Compare	6/78	4/30	-	3/18	0%	0% (-18%, 36%)	+1	-2	0
	Total	**11/144**	**8/90**	**9/90**	**8/54**	-	**13.3% Omnibus**	-	-	-
Participant 7	Change	3/18	9/30	11/60	3/18	20%	0% (-38%, 51%)	+1	-3	+1
	Combine	4/48	4/30	3/30	3/18	20%	20% (-10%, 58%)	+0.5	+2.5*	0
	Compare	8/78	4/30	-	2/18	0%	0% (-18%, 36%)	0	-2	0
	Total	**15/144**	**17/90**	**14/90**	**8/54**	-	**6.7% Omnibus IRD**	-	-	-

*** indicates effect based on a 2 point change in scores and PND > 70 and IRD > 50**

CHAPTER 6

DISCUSSION

6.1 Introduction

This chapter discusses the results obtained in this study. Relevant literature is referred to so as to explore possible factors that may influence the results in terms of participant selection criteria (participant) factors and pedagogical (intervention) factors. This discussion is elucidated through perusal of pertinent literature and comparison to other studies that focused on word-problem solving.

6.2 Effect of the MAiLgS programme on subtraction word-problem solving

The results of the probe tests administered during the initial baseline, intervention, post-intervention and maintenance phases reveal benefit for three out of the seven participants across each of the three types of subtraction word-problem solving. One participant demonstrated an improvement in the change and combine types of word problems but not in the compare word-problems. A positive, accelerating trend is evident in results across the intervention phases for these four participants since their results continued to improve with continued exposure to the intervention. Three participants did not demonstrate an improvement in any of the types of word-problem and their results were inconsistent across the intervention phases.

Consideration of participants' performance during the initial baseline phase suggests that they experienced difficulty with solving subtraction word-problems independently, given that the participants scored mostly between 0 and 2 out of a possible six correct answers. In comparison, during the maintenance probes following intervention, four of the participants scored on average 4.8 out of a possible six correct answers, which suggests that these participants were able to solve some of the subtraction word-problems independently. Moreover, since the maintenance probes were administered four weeks after termination of the intervention for compare word-problems, these participants had maintained their ability to independently solve each of the three types of word-problem.

When initial and maintenance probe scores are compared, four participants demonstrated improvement, with Participant 4 showing the most improvement following implementation of the MAiLgS programme. The other three participants did not seem to benefit from the MAiLgS programme when their individual graph profiles are analysed. It is interesting to note, however, that comparison of the initial baseline and maintenance probe scores of these three participants revealed improvements, albeit at lower levels than those reflected by the other four participants. Accordingly, average improvement scores between these phases of the four participants that seemed to benefit from the MAiLgS programme were 3.57, 4.4, 4.5 and 5. In comparison, the three participants who did not demonstrate benefit had average improvement scores of 0.14, 0.2 and 0.5 respectively.

In an attempt to understand the variability between the participants' performance regarding the effect of MAiLgS on the participants (with three participants not showing an effect and four having an effect), possible factors that may impact on subtraction word-problem solving need to be explored. This is done by comparing the results of this study to others that also focused on word-problem solving. Furthermore, pertinent literature is also consulted to investigate these reasons.

6.3 Factors related to the participant selection criteria

In an attempt to create a homogenous group for this study, 12 stringent selection criteria were used for the selection of participants, as discussed in Section 3.6.2. This was important to ensure that individual differences between participants did not introduce extraneous variables that could influence the performance of participants and for participants to be described in some detail (Sevcik, Romski & Adamson, 1999). The selection criteria used are essentially child-related factors in that they describe the characteristics of the participants and refer to their abilities in the areas pertinent to this study. Consultation of literature informed the compilation of selection criteria in terms of those factors that could affect mathematical word-problem solving, and those selection criteria are consequently elaborated upon.

6.3.1 Receptive vocabulary

The PPVT-IV (Dunn & Dunn, 2007) was used to determine the receptive vocabulary of participants. Measuring receptive vocabulary competence is central to this study, given that its focus is on improving receptive vocabulary for mathematical word-problem solving specifically. Accordingly, the argument is that participants would need to have similar receptive vocabulary. They should, therefore, be able to understand the terminology used during the intervention phase and probe tests of the study, given that mathematical language may vary in meaning to everyday language (Vukovic & Lesaux, 2013a).

Considerable research has explored the effect of language on word-problem solving, and the literature emphasises the fundamental role that language plays when solving word-problems (Bernardo, 1999, 2002; Cummins, 1991; De Corte & Verschaffel, 1987; Powell, 2011; Schumacher & Fuchs, 2012; Vukovic & Lesaux, 2013a, 2013b). Essentially, these studies posit that language ability generally impacts on word-problem solving with regard to interpretation of the words. As a result, the effect of language on word-problem solving may be explored in terms of two elements.

The first element pertains to the actual meaning of the words, which may be misinterpreted and thus lead to errors in solving the word-problems. An example of this relates to one of the combine-types of word-problem as used in this study, where children misinterpret the word "altogether" to mean "each" and thus solve the word-problem incorrectly (Cummins, 1991; Verschaffel & De Corte, 1993). As a matter of interest, this finding was also observed in this study where some participants gave both "Zinzi" and "Joe" the number of manipulatives that they should have had together. Relational terminology relating to the compare type word-problems was explored in a study by Schumacher and Fuchs (2012), since this type of word-problem is arguably the most difficult of the three types due to a static relationship being described as well as the presence of relational terminology (De Corte, Verschaffel & De Win, 1985; Fuson, Carroll & Landis, 1996; Schumacher & Fuchs, 2012). In the study of Schumacher and Fuchs (2012), positive results were achieved by children when the defining features of compare-type word-problems were taught to them. In the present study, the MAiLgS programme similarly facilitated solutions of the compare-type word-problems for four participants.

The second element relating to the effect of language on word-problem solving involves the actual structure of the word-problems. Some studies have examined the effect of changing the structure or word order of the word-problems in an attempt to enhance their clarity and found this strategy to be effective (Bernardo, 2006; De Corte et al., 1987; Schumacher & Fuchs, 2012). In this study the word structure originally proposed in the Riley et al. (1983) model was used with only the names of the characters and objects being changed. Since four of the participants demonstrated improved word-problem solving skills following implementation of the MAiLgS programme, it would seem that changing the wording of the word-problems was not critical for the participants in this study.

Consideration of the aforementioned elements reveals that four of the participants were successful in overcoming them following implementation of the MAiLgS programme, while three participants were unsuccessful. In an attempt to explain this, the receptive scores achieved by participants in the PPVT-IV were contemplated in light of their performance in the probe tests. A critical finding was evident that may elucidate the discrepancy between the performance of the participants. Accordingly, the receptive skills as measured by the PPVT-IV for the three participants who demonstrated the least improvement in the probe tests also had the lowest scores for receptive vocabulary. The receptive vocabulary for each of these participants coincidentally scored at the lower limit of 4;2. This was 10 months lower than the receptive vocabulary score achieved by two other participants, who both happened to show improvement in their word-problem solving skills. Participant 4, whose probe tests levels were highest, demonstrated the second strongest receptive vocabulary, scoring at 7;5 while participant 2 whose receptive vocabulary scored highest at 7;5 was one of the other participants who scored higher in the probe tests. This observation appears to emphasise the necessity of supporting receptive language to enhance understanding and is supported by other studies that focused on enhancing receptive language skills (Dada & Alant, 2009; Romski & Sevcik, 1993).

6.3.2. Language of learning and teaching (LoLT)

The selection criterion regarding the LoLT required participants to be exposed to English as the LoLT for a minimum of two years. In South Africa and more particularly in the Gauteng province, children are often multilingual (Bornman et al., 2011; Jordaan, 2011; Statistics South Africa, 2012) as observed during the two pilot studies and main study, inter alia. However, English was used as the LoLT in this this study due to its dominance as the LoLT in South African schools (Adler, 1997; Department of Basic Education, 2010; Jordaan, 2011; Van Laren & Goba, 2013). Participants thus needed to have a functional understanding of English to enable them to understand the words used during the presentation and explanation of the word-problems in the intervention phase. Furthermore, participants would need to be able to understand the wording of word-problems read to them when solving them during the probe tests.

Studies on bilingualism (e.g. Bernardo, 1999, 2002) have revealed that students perform better in understanding and solving word-problems and learning (Jordaan, 2011) when these are presented in their first language. Other studies similarly revealed that children who did not learn mathematics in their first language, underachieved (cf. Howie, 2005; Reddy, Kanjee, Diedricks & Winnaar, 2006). As a result, since English was used in this study, participants whose first language was not English could be expected to be disadvantaged, and more so if they had received instruction in English for too short a period of time. Bernardo (1999) explains that different languages may not necessarily access the same conceptual systems, and given the eleven official languages in South Africa, the order in which words are used in different languages as well as the translation of words must also be considered (Van Laren & Goba, 2013). Of the seven participants, four had English as their first language, two had isiZulu and one had Siswati. However, according to the LeSTE, each participant had been exposed to English as the LoLT for more than two years.

When considering the effect of the LoLT and first language of participants on their performance during word-problem solving, there is no indication that having a first language other than English negatively impacts on word-problem solving. This supports the results reported by Jordaan (2013) regarding bilingual preschool children who had been exposed to English as the LoLT for at least one year and performed on similar levels to the monolingual peers. This is reflected with regard to Participant 4, whose first language is isiZulu but who scored highest in the word-problem solving probe tests. Furthermore, Participant 6 who scored as one of the lowest in the probe test has English as her first language.

6.3.3. PCS symbols identification

For this study participants were required to correctly identify 90% of the PCS symbols on the fourth trial. This means that participants were exposed to the PCS symbols to be used in the intervention programme four times. Given that PCS symbols form the basis of the aided stimulation principles that were operationalised in this study, it was imperative for participants to be able to identify the symbols spontaneously, and a cut-off point of 90% was thus decided upon as used in the work of Binger and Light (2007) and Dada and Alant (2009). This criterion was modified after the first pilot study and used in the modified form during the second pilot study where it yielded better results. Harris and Reichle (2004) and Schlosser and Lloyd (1997) employed a similar strategy whereby participants were asked to match symbols.

Since PCS symbols were used as labels during lessons at the school daily, participants appeared to be familiar with some of them and consequently scored well in the PCS symbol Identification Test. Accordingly, three of the participants scored at 100% when identifying PCS symbols after the fourth day. The other four participants all achieved scores of 94%. When exploring the relationship between participant performance in the probe tests and PCS symbol identification, it is apparent that the participants who scored highest in the probe tests all scored 100% in identifying PCS symbols. Furthermore, for the participants who scored at 94% accuracy in identifying PCS symbols, their performance in the probe tests was also lower. This suggests that graphic symbol awareness (in this case, PCS symbols) was central to benefitting from intervention that included graphic symbols as a primary intervention tool.

A further deduction can be made by combining the results and findings of the receptive vocabulary test with that of the PCS symbols Identification Test, which may help to explain why three of the participants in the group scored lower during their probe tests. For each of these participants, their receptive vocabulary and PCS symbols identification scored lowest across the participants. Lower performance in these two areas, which target the core features of the MAiLgS programme, seems to have had a negative impact on these participants' ability to solve subtraction word-problems effectively. The other four participants achieved higher scores in both receptive vocabulary and PCS symbols identification and also scored higher in the word-problem probe tests. One could argue from this that stronger receptive language skills enhance mathematical word-problem solving.

6.3.4 Mathematical knowledge

The selection criterion relating to mathematical knowledge required participants to achieve an age-equivalent score of between 4;0 and 8;0. This criterion was in line with that of the required receptive vocabulary skills. For participants to understand the subtraction word-problems used during the intervention programme, it was important for them to have an elementary knowledge and understanding of mathematical concepts.

Accordingly, the mathematical subtests of the WIAT-II (Wechsler, 2005) were used to ascertain each participant's functional mathematical level. Similar practices are evident in other studies where researchers administered both problem-solving and calculation tests in an attempt to establish equivalence between participants (Schumacher & Fuchs, 2012; Vukovic & Lesaux, 2013b). When the WIAT-II scores of participants were reviewed, it may be assumed that existing mathematical knowledge may have facilitated word-problem solving skills, given that Participant 4 scored highest (at 7.00 for numerical operations and 6.00 for mathematical reasoning) in these subtests of the WIAT-II and also demonstrated the highest probe test levels in the study. However, this pattern was not apparent for Participant 1, whose probe test levels scored second highest, but her scores in the WIAT-II were similar to the three participants who scored lowest in the probe tests. Participants 3 and 7 scored lowest in the WIAT-II and were two of the three participants who scored lower in the probe tests. As a result, it cannot be argued with certainty that underlying mathematical knowledge enhances the word-problem solving abilities of children with intellectual disabilities. This aspect, therefore, requires further investigation.

6.3.5 Chronological age

This criterion was set between 8;0 and 12;0. In the study by Bernardo (1999) children across three grades were given change, combine and compare word-problems to solve independently. As expected, the older children performed on a higher level when solving the word-problems than their younger counterparts. The error analysis in Bernardo's (1999) study revealed discrepancies across word-problem types with regard to the interpretation of the wording as well as the operation used to solve the word-problems.

In this study, similar findings are reflected for some participants. The three oldest participants are aged 11;6, 11;6 and 11;5. The other four participants are younger, aged 9;0, 9;7, 9;10 and 9;10. Of the older participants, two had higher omnibus IRD scores at 80% and 67% respectively. The younger participants reflected lower omnibus IRD scores at 13.3% and 15.67% respectively. The results of these four participants are in keeping with the findings of Bernardo (1999) who found that older children outperformed the younger ones, given that they would have had more opportunity to develop their schematised knowledge of word-problems and thus were able to operationalise this knowledge more spontaneously. Surprisingly, the performance of the other three participants contradicts this finding, since the older participant (11;6) scored a lower omnibus IRD at 6.67% and the two younger participants (both 9;1) scored higher omnibus IRD scores of 60% and 68% respectively. Their results suggest that factors other than only their chronological age impacted on their word-problem solving ability.

6.3.6 Intelligence Quotient (IQ)

An IQ of between 40 and 69 as measured by the KBIT-2 (Kaufman & Kaufman, 2004) was the second selection criterion indicated for this study. Of the studies identified that explored word-problem solving and more especially used the three types of word-problem used in this study, none of them included participants who could be described as having an intellectual disability. Of the studies, Bernardo (1999) used two groups of participants for each of the three grades in terms of academic achievement; they were consequently referred to as low-achieving or high-achieving, instead of being grouped according to their IQ. When each group was compared within the respective grades, the low-achieving participants consistently scored lowest when solving the word-problems. In their study that explored whether understanding relational terminology in compare-type word-problems improved word-problem solving skills, Schumacher and Fuchs (2012) grouped their participants as being either "at-risk" or "not-at-risk". They only analysed their results for the "not-at-risk" children, which indicated that teaching these children to understand relational terminology for the compare type word-problems is important. They excluded analysis of the results for the "at-risk" children for two reasons. Firstly, these children received tutoring in addition to the intervention, which could have affected their responsiveness to the intervention. Secondly, the sample size of "at-risk" children to determine effect may have influenced the mediation analysis.

In contrast to the study of Schumacher and Fuchs (2012), in this study, all participant results were analysed. The analysis revealed that there was not a positive relationship between the respective IQ scores and probe test results, although this may have been expected. Accordingly, Participant 2 presented with the highest IQ score but did not perform highest in the word-problem probe tests. Participant 4 showed substantial improvement between the initial baseline and maintenance phase probe, but when comparing that to his IQ score, he unexpectedly had the third-lowest IQ score. Participant 7 had the lowest IQ score of all the participants but scored higher in the probe tests than two other participants in the study. It is important to acknowledge, though, that he was one of the participants who scored lowest in the study. This incongruence may be explained when the work of Rosenzweig, Krawec and Montague (2011) is considered. The research that these authors refer to (cf. Van Luit & Kroesbergen, 2006) confirms that metacognition develops along with aptitude, and many research projects have found that metacognition may actually account for up to 75% of the observed performance variance. Since metacognition was not included in this study, comment must be reserved as to the potential effect of metacognition on the participants' performance.

6.3.7 Concentration

In this study concentration was defined as the ability to focus on a task for approximately 20 minutes. This is particularly relevant to group-instruction strategies, where it is not always possible for the facilitator to monitor the individual concentration levels of all participants. Furthermore, being able to concentrate for the allocated time during a lesson is important for children to be able to conceptualise and learn from what is being taught. Perusal of the studies consulted (Andersson, 2006; Krawec, 2104; Owen & Fuchs, 2002; Schumacher & Fuchs, 2012; Swanson & Sachse-Lee, 2001; Swanson, Lussier & Orosco, 2013a; Swanson, Lussier & Orosco, 2013b; Swanson, Lussier & Orosco, 2014; Swanson et al., 2013; Van Garderen & Scheuermann, 2014; Van Garderen et al., 2012) revealed none that used concentration as a selection criterion. However, 20 minutes was deemed to be a reasonable expectation for the following three reasons:

i) The two pilot studies conducted prior to the main study demonstrated that 20 minutes was a realistic time frame for participants to remain focused on the intervention, since each of the 10 pilot study participants demonstrated this ability;

ii) The LeSTE that was completed for each participant by their class teachers indicated that the participants were able to attend for a period of 20 minutes during class activities, which coincides with the intervention format for the study;

iii) As imparted in the LeSTE, none of the participants had ADD or ADHD as a primary diagnosis (which could potentially have affected concentration). It is also important to acknowledge that although three participants in the first pilot study did have a primary diagnosis of ADHD, they were nonetheless able to attend adequately for 20 minutes.

As a result, when comparing attention to participant performance in this study, lower performance in the probe tests cannot be definitively attributed to concentration fluctuation.

6.3.8 Summary of factors related to the participant selection criteria

In order to explain and clarify the performance of participants in this study as to whether their results reflect intervention effect, various factors that are related to the participants were discussed. From the preceding discussions it would seem that the receptive language proficiency of three participants was insufficient to facilitate optimal word-problem solving. Linked to this was their lower PCS symbol identification. Together these skills form a crucial part of the MAiLgS programme and although these participants did score within the stipulated cut-off points in the selection criteria, their scores were nonetheless lowest across participants. Another consideration is the avoidance of using manipulatives during the probe tests by these participants. While these are tentative hypotheses, it is also important to explore pedagogical factors that may also have impacted on the performance of participants.

6.4 Pedagogical factors pertinent to participant results

In this section, the respective pedagogical factors that may have impacted on the results achieved by the seven participants in the probe tests are explained. These include the instructional variables that are effected during the intervention programme as well as the nature of the word-problems themselves.

6.4.1 Instructional variables

When discussing instructional variables, the instructional design used is referred to. When the relevant literature is perused, it is apparent that considerable debate surrounds which instructional designs are best suited to teaching children with various learning needs. However, from the literature consulted, it would seem that the predominant focus on instructional design relates to children who present with mathematical disabilities or are 'at-risk' learners. Literature relating to instructional design for children with intellectual disabilities in mathematics appears to be meagre.

6.4.1.1 Predominant instructional designs for teaching word-problem solving

Although not specifically related to teaching children with intellectual disabilities, various instructional designs seem to be used for teaching word-problem solving as discussed in Section 2.4.2 (Gersten et al., 2009). While these designs have been used with children with learning disabilities, their utility for children with intellectual disabilities may have merit.

In the meta-analysis done by Gersten et al. (2009), regression analysis was used to compare instructional designs and explicit or direct instruction seems to be the design of choice when teaching word-problem solving. As noted by these authors, the term "explicit instruction" is defined in various ways. However, they explain that there must be three central features in order for an instructional design to be labelled as explicit instruction. The first feature relates to the teacher demonstrating a strategy in a step-by-step way to solve word-problems. The second feature requires that the strategy be specific to a set of problems rather than generalised. The third feature involves the child using the same strategy as the one demonstrated by the teacher.

In this study, explicit or direct instruction was selected for the MAiLgS programme, given its limitation of strategies taught that seem to work most effectively for children with intellectual disabilities specifically (see Section 2.4.2). When compared to the three features described by Gersten et al. (2009) it is apparent that the MAiLgS programme incorporated all of them. Firstly, the researcher fulfilled the teacher role and used a script to teach a step-by-step strategy to solve the given word-problem type. Secondly, for each type of word-problem, a specific strategy was taught. Finally, although participants watched the demonstration of the strategy during the intervention phase for each word-problem type, they were expected to use the taught strategy in the same way when given manipulatives and an A3 replica of the facilitator board.

This process was adhered to for each of the 15 intervention sessions to which participants were exposed. This was intended to result in the strategy becoming more predictable to participants as the sessions progressed. Apart from being exposed to direct instruction during the intervention phase, it is also important to explain that direct instruction was done in a group format rather than with individual participants. The reason for this was twofold. Firstly, using a group would allow participants to receive the same intervention under the same conditions and thereby ensure procedural integrity (Dada & Alant, 2009). Secondly, given that most learning occurs in group situations in schools, exploring the MAiLgS programme using a group format would give an indication of the potential use of the programme in schools. This reflects the practice of current intervention studies that have a “real-life” focus whereby the research is conducted within school settings so as to enhance the generalisability of the results (Carbonneau et al., 2013; Schumacher & Fuchs, 2012).

When the individual graphs of participants were consulted, it would seem that the repetition of a given strategy was in fact beneficial, since Participants 1, 2, 4, 5 and 6 all reflected improved scores from intervention into post-intervention, suggesting that they had internalised the strategy for change type and combine type word-problems. Since a post-intervention phase was not possible for the compare-type word-problems, a similar deduction can unfortunately not be made.

6.4.1.2 Concrete apparatus

As described in Section 3.7.2.11 and referred to in Section 4.4.5, concrete apparatus was used during the teaching of the strategy for each word-problem type. The concrete apparatus comprised an A1-sized facilitator board for the facilitator, and each participant had an A3 replica of the facilitator board. The facilitator and each participant also had 20 opaque, convex, flat-based manipulatives.

Consideration of work done that explores the use of manipulatives in mathematics explains that manipulatives are intended to facilitate the process of learning targeted information through physically manipulating concrete objects (Carbonneau et al., 2013; Verschaffel & De Corte, 1993). This lends itself specifically to the dual-coding theory of Paivio (1980, 1986, 2006) as explicated in Section 2.5.1. Carbonneau et al. (2013) explain that when children use manipulatives to solve word-problems they have access to verbal information in the form of word-problems as well as nonverbal information relating to how the manipulatives are used to find word-problem solutions. Furthermore, studies cited by Carbonneau et al. (2013) suggest that children seemed to benefit more from instruction that includes the use of manipulatives.

Since the probe tests were video recorded as mentioned in Sections 3.8.4, it was possible to ascertain whether participants used the manipulatives in keeping with the strategies taught during the MAiLgS programme and to see whether they correctly counted the manipulatives. It was evident that Participants 1, 2, 4 and 5, who demonstrated an improvement following intervention, all used the manipulatives to represent the oral word-problems in a concrete manner (Bruner, 1964; Piaget, 1962) and did so correctly. They were thus able to access both the verbal form of the word-problems as well as the nonverbal information related to how manipulatives were used to solve the word-problems, which suggests effective dual-coding of the available information.

It is, however, interesting to note that of the three participants who did not show an improvement following implementation of the MAiLgS programme, not one of them used the manipulatives during most probe tests, despite having them available on their tables. Viewing of the video recordings revealed that Participant 3 never took the manipulatives out of the box. Participant 6 did try to use them for a few isolated probe questions although she generally left them untouched. Participant 7 put his manipulatives out and on occasion moved them around on his table, but through observation it was apparent that he was not using them to solve the word-problems but to make random patterns instead.

When exploring these observations, the researcher hypothesises that these three participants could not relate the manipulatives to the word-problems in a meaningful way despite having been exposed to the teaching of six word-problems every day for three weeks. This hypothesis would suggest, essentially, that these participants were unable to activate the nonverbal representation of the word-problems from the verbal representation of the word-problems (Clark & Paivio, 1987). However one may argue that these participants may have felt more comfortable with using an alternative solution method, as observed by De Corte and Verschaffel (1987), where manipulatives were provided but not always used by participants. However, although children with a chronological age of more than 8;0 can be expected to make visual representations of word-problems (Van Garderen & Montague, 2003) none of the participants in the present study opted to do so despite having the means.

6.4.2 The nature of word-problem solving

How the nature of word-problem solving impacted on participant performance is elucidated firstly by considering the structure and complexity of the word-problems used. Secondly, for children to solve the word-problems two primary models need to be operationalised. The first model entails creating mental representations in accordance with either the situation or problem model of the word-problems based on information from the second model, which may be either linguistically or mathematically related. Although these models have a reciprocal relationship within the framework of this study, they are discussed separately in an attempt to facilitate analysis of participant performance.

6.4.2.1 Structure of the three types of subtraction word-problems

During the development of the MAiLgS programme, consultation of literature and research pertaining to the Riley et al. (1983) model revealed that the subtraction word-problems selected for this study varied in terms of the type (change, combine and compare) as well as the level of cognition required to solve them. Riley and Greeno (1988) conclude that the developmental and learning stages of children are aligned to each of the levels of word-problem solving. It was therefore decided to focus only on the word-problems that tapped level one solutions; which were believed to correspond with the learning stages of the participants in this study. This entailed exposing the participants to the change, combine and compare word-problem, which required external models to be created using concrete apparatus, as discussed in Section 4.4.5.

Analysis of the performance of participants in each of the three types of word-problem reflects the findings of Riley and Greeno (1988). Participants 1, 2, 4 and 5 evidently commanded the general ability to create accurate external representations of the change-type and combine-type word-problems using the manipulatives. This in turn seemed to operationalise the specific knowledge that facilitated understanding the wording of the word-problems. Together, these abilities enabled these four participants to derive accurate solutions. In contrast, creating accurate external representations of the change-type and combine-type word-problems were noted to be challenging for Participants 3, 6 and 7. As a result, they were evidently unsuccessful in tapping the specific knowledge that would promote wording comprehension and result in correct solutions. According to Riley and Greeno (1988), insufficient linguistic and conceptual knowledge comes into effect when attempting to solve the more complex compare-type word-problems. In this study, this difficulty was noted for Participants 3, 5, 6 and 7. Viewing of the video recordings revealed that in keeping with their practice in the other word-problem types, Participants 3, 6 and 7 did not use the manipulatives to attempt solutions, and it may possibly be deduced that their linguistic and conceptual knowledge was inadequate to solve the compare-type word-problems. However, viewing of Participant 5 revealed that while she seemed to employ her conceptual knowledge to create external representations of the compare-type word-problems, her linguistic knowledge inhibited her ability to realise that she had to disregard the equivalent manipulatives and only count those that were left over. Instead, she only focused on the manipulatives that were less (e.g. for the compare type word-problem: *ZINZI HAS 8*

SWEETS. JOE HAS 1 SWEET. HOW MANY SWEETS does JOE HAVE LESS than ZINZI? Participant 5 gave 1 as her answer). Participants 1, 2 and 4 nonetheless were able to solve the compare-type word-problems, suggesting that their general ability and specific knowledge for this word-problem type facilitated their solutions.

6.4.2.2 Situation and problem models mental representation

Apart from consideration of the structure of word-problems, processing and understanding the word-problems and translating the words – whether written or spoken – into mathematical information is imperative. This process involves constructing two types of mental representation which are referred to as problem and situation models (as described in Section 2.3.1.1) (Riley & Greeno, 1988; Rosales et al., 2012; Tolar et al., 2012).

In this study, an attempt was made to encourage participants to solve word-problems in a “genuine” way (Rosales et al., 2012, p. 1186). This involved facilitating the generation of a situation model of each word-problem first (Brissiaud & Sander, 2010) whereby the relevant information was emphasised and irrelevant information ignored. This was done during the teaching of the word-problems where the first phase of the MAiLgS programme was operationalised by using aided language stimulation principles (Goossens’, 2000) to explain the wording of the word-problems. This resulted in the relevant information being used to create a suitable problem model which involved the second phase of the MAiLgS programme, namely representing the word-problem using the manipulatives that would allow the solution of the word-problem to be determined. When the results of Participants 1, 2, 4 and 5 are considered it would seem that the MAiLgS programme was successful in enabling them to create situation and problem models for each of the three types of word-problems, which facilitated the solution of the word-problems.

It is possible then that the other three participants whose scores do not seem to benefit from the MAiLgS programme tried to solve word-problems on a "superficial" level (Rosales et al., 2012). Accordingly, linking to the role that receptive vocabulary seems to have played for these participants, it potentially follows that because they experienced difficulties with the specific knowledge required to understand the wording of the word-problems, these participants were unable to create a situation model and then problem models where manipulatives were used correctly to represent the presented word-problems. This in turn possibly resulted in random strategies being used, such as identifying a familiar or key word in the word-problem and solving the word-problem based on this information without using the manipulatives. When using this approach, participants would not be expected to check that their solution was meaningful (Rosales et al., 2012). This expectation is supported through viewing the video recordings, which showed that these three participants never checked their solutions.

6.4.2.3 Linguistic developmental and logico-mathematical views of word-problem solving

In order for children to create situation and problem model representations of word-problems, they need to make sense of the word-problem information. This entails interpreting the verbal or graphic representation of a word-problem and manipulating the information in order to come to a solution that refers to the linguistic aspect of the word-problem (Cummins, 1991). In the model of Riley et al. (1983, 1988) children need to understand the semantic information of the word-problems so that they are able to link this information to suitable solutions (Cummins, 1991). Difficulties in this area can result in solution errors, since misinterpretation of words in a word-problem can change the meaning of the word-problem, which in turn influences the strategy used to solve the word-problem (Verschaffel & De Corte, 1993). This is especially relevant, for example, to subtraction word-problems where children opt for using solution strategies that most closely resemble the semantic structure of the word-problem (De Corte & Verschaffel, 1987). In this study this finding was observed where some participants gave Zinzi and Joe each six sweets for the combine type word-problem, which stated that Zinzi and Joe have six sweets together.

Consequently, in an attempt to reduce the interpretation of irrelevant information in word-problems to allow participants to focus on relevant information, consistent use was made of the names Zinzi and Joe for the children and sweets for the items being manipulated. Bernardo (2002) evidently used a similar strategy for his participants who were bilingual. Within the MAiLgS programme, aided language stimulation principles were also used to further enhance and elaborate on the semantic structure of the word-problems, since optimal understanding of the wording is argued to facilitate correct solutions.

This sequence of events in the solution process cannot, however, be guaranteed, given that logico-mathematical knowledge then also comes into play. How the children employ this knowledge to further interpret the word-problems dictates success in finding the solution (Cummins, 1991). Within the Riley et al. (1983, 1988) model, understanding part-whole relationships comes into effect here. Consequently, should children not have developed a solid understanding of these relationships; they may experience difficulties with solving word-problems. In this study, manipulatives were used to represent the part-whole relationships to support solving the word-problems. During this process, though, semantic schemata are used to determine which elements of word-problems are whole and which are only parts (Cummins, 1991). Again, the importance of understanding the wording is emphasised, since not understanding the difference between a whole and a part can be expected to prevent children from employing their logico-mathematical knowledge to develop a problem model.

There appears to be interplay between semantic and logico-mathematical knowledge when the results of participants in this study are considered. For those participants who understood the semantic structures of the word-problems, employing their logico-mathematical knowledge to further interpret word-problems was possible. This in turn facilitated the development of a problem model and a solution could thus be obtained. The three participants who scored lower in the receptive vocabulary test appeared to experience challenges with interpreting the semantic information, which prevented them from linking this knowledge to their logico-mathematical knowledge. In turn they were unsuccessful in developing a situation and then a problem model representation of the word-problems.

6.4.3 Summary of pedagogical factors

Direct instruction in a small group was selected for this study. It allowed participants to receive the same exposure during the MAiLgS programme while being taught a strategy to solve each word-problem type. Consideration of hierarchical structure of the Riley et al.'s (1983) word-problems that can be solved on three different levels may be seen to influence solutions, depending on the developmental and learning stage of the children. The interplay between the linguistic and logico-mathematical models that are operationalised in this model and the development of situation and problem models that represent the word-problems appropriately, accentuates the importance of facilitating and enhancing these processes to optimise word-problem solving.

6.5 Conclusion

When analysing the performance of the seven participants in this study it is necessary to explore the reasons why four participants demonstrated intervention effect while the other three did not. To do this, selection criteria factors and pedagogical factors were explored as possibly contributing to these findings. Essentially, the most significant reason for lower performance in the MAiLgS programme seems to be weak receptive language skills, which have a compounding effect on word-problem solving. This is because receptive language skills, through the specific knowledge referred to by Riley and Greeno (1988), form the foundation for the employment of semantic and logico-mathematical knowledge. Together, this knowledge is posited to facilitate the development of mental representations within the situation and problem models necessary for accurate word-problem solving. As such, this finding evidently confirms the argument of the study, which is that receptive language skills are fundamental to effective subtraction word-problem solving by children with intellectual disabilities.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

This chapter presents a summary of the study findings as well as conclusions regarding the effect of the MAiLgS programme used during intervention. A discussion of the clinical implications of the research findings follows. Thereafter, an evaluation of the study in terms of strengths and limitations is undertaken. Finally, recommendations for future research are made.

7.2 Summary of findings

The main aim of this study was to determine the effect of an MAiLgS programme on three types of subtraction word-problem solving skills of children with intellectual disabilities. The programme lasted for three consecutive weeks and subtraction word-problem solving skills were measured daily using probe tests.

When the effect of the MAiLgS programme on subtraction word-problem solving for children with intellectual disabilities is considered, it is evident that four of the seven participants demonstrated a positive effect. This suggests that the MAiLgS programme was effective in improving their subtraction word-problem solving skills. Following withdrawal of the intervention for four weeks, these four participants achieved scores similar to their scores obtained during the probe tests administered during the intervention phase, which suggests that they had maintained the skills taught during the intervention phase. For the remaining three participants, negligible effect following the implementation of the MAiLgS programme was evident. Following withdrawal of the intervention for four weeks, no improvement was evident in the scores for these participants, confirming that they had not retained subtraction word-problem solving skills during the intervention phase.

7.3 Clinical implications of the study

The main clinical implication is that supporting word-problems with augmented input and graphic symbols seems to facilitate the subtraction word-problem solving skills of some children with intellectual disabilities. This suggests that the elucidation of word-problem terminology had a positive effect on their word-problem solving skills. Literature suggests that children with intellectual disabilities are not typically exposed to mathematical word-problem solving as it is believed to be too difficult for them to understand. However in this study, where all seven participants presented with a moderate intellectual disability (IQ below 70), four were successful in solving word-problems following the MAiLgS programme. Accordingly, it is postulated that children with intellectual disabilities may indeed be able to acquire word-problem solving skills if appropriate instruction is used.

A second implication is that this study mimicked a classroom context in which the subtraction word-problem solving skills for some children with intellectual disabilities were improved. The MAiLgS programme was facilitated by the researcher, who assumed the role of a teacher. In view of that, it is believed that such a teacher-led strategy is feasible for use by teachers during mathematical word-problem solving lessons. Moreover, the small-group format that was used proved to be effective in facilitating word-problem solving. The clinical implication is that children with intellectual disabilities may be included in a small group to learn word-problem solving rather than be taught one-on-one, which was previously believed to be the only effective intervention strategy for complex concepts such as word-problem solving. This practice would have further positive implications for children with intellectual disabilities in terms of learning with their peers, where collaborative learning may be realised. Essentially, the teaching method employed in this study promotes the employment of group instruction for children with intellectual disabilities.

A third implication, specifically for low- and middle income countries such as South Africa, is that the cost-effective, low-technology AAC system in the form of the facilitator board, scripts and manipulatives used in this study proved to be effective for some children with intellectual disabilities. Accordingly, even teachers in rural areas where resources are limited, would be able to make their own facilitator boards and use materials in their immediate environment as manipulatives.

7.4 Evaluation of the study

7.4.1. Strengths of the study

The main strength of this study relates to the design used. The multiple baseline design with withdrawal used allowed for replication of the intervention across three types of behaviour for each participant as well as replication across participants. The withdrawal of intervention enabled a maintenance phase to be introduced as well.

Furthermore, since the intervention was presented using a small-group format, it was possible to ensure that all participants were exposed to exactly the same intervention at all times. This essentially also facilitated rating the consistency with which the intervention was implemented. The presentation in a group format is also consistent with the principles of group therapy as opposed to one-on-one intervention and mimics the real life classroom context.

The MAiLgS programme incorporated practical and logistical "real-life" considerations into the programme, which evidently increased its practicality and suitability for classroom implementation. The five-day period coincided with the academic teaching week. Intervention was provided in a small-group format. The probe tests during the initial baseline, intervention and maintenance phases were also done in the small-group format. Having the participants complete the probe tests in the small group similarly allowed each participant to be exposed to the probe tests in exactly the same manner. In addition, maintenance could be measured after a four-week withdrawal period. Additionally, the MAiLgS programme included the use of concrete apparatus such as manipulatives and the facilitator board which is usually available in classrooms.

A further strength relates to the procedural integrity evident in this study, with inter-rater reliability for the procedures and probe tests being consistently high over the whole duration of the study.

The use of IRD calculations to supplement visual analysis can be regarded as another strength of the study. It provides an indication of the effect size, which gives an indication of the amount of change between the initial baseline and intervention sessions (Parker et al., 2009).

7.4.2. Limitations of the study

While an effect of MAiLgS on the subtraction word-problem solving for four children with intellectual disabilities was evident, this effect was not evident for three of the participants. Possible reasons for the variations amongst participants are explored.

A limitation pertains to the types of subtraction word-problem used in this study. As a result, the effect of the MAiLgS programme cannot be guaranteed for other mathematical operations such as addition.

The third limitation suggests that since the subtraction word-problems used during the probe tests were identical to those used during the intervention phase, generalisability of the skills to word-problems having different children, objects (e.g. dolls instead of sweets), operations (i.e. addition, multiplication or division) and numbers is questionable (Powell, 2011).

The fourth limitation relates to the practical considerations of the small-group format for intervention. Because the small-group format was used for the study, intervention had to be initiated even if participants did not have stable baselines as the group had to work simultaneously. In so doing stable baselines were not achieved for all participants in each word-problem type.

7.5 Recommendations for future research

A comparative study comparing two interventions could be used. Use of a control group with which to compare the results of participants is suggested. This would allow for the use of a pretest – post-test control group design. In this way one group would receive the MAiLgS intervention while the control group received traditional instruction for word-problems (Riley et al., 1983).

While the stipulations of Goossens' (2000) were used in terms of the frequency of MAiLgS to be used as well as the nature thereof, further investigation of the amount of aided language stimulation required to improve word-problem solving is recommended. Such enquiry would be helpful in guiding teachers to provide adequate yet effective augmented input. Hence, a comparative study with various amounts of aided input is indicated to explore this further. An adapted alternating research design would allow each type of word-problem to be implemented at a specific percentage of aided language stimulation, with the dependent variable being the number of correct responses.

Although the MAiLgS programme proved to be effective in enhancing three types of subtraction word-problem solving for some children with intellectual disabilities, its effect with the more complex word-problems that require higher levels of problems-solving warrants further exploration. This exploration could enlighten teaching practice for children both with and without intellectual disabilities.

Replication of this study with word-problems that employ a different operation namely, addition is recommended. This would shed light on the effect of the programme on each type of word-problem and also allow for comparison of the intervention between operations.

While concrete apparatus in the form of manipulatives was used in this study, literature suggests the values of other forms of representing word-problems. Accordingly, the effect of other forms of concrete apparatus (e.g. abaci, number lines, drawings of objects or representations as advocated by Krawec (2014)) together with the MAiLgS programme should be explored, as this may offer children word-problem representations best suited to their learning needs.

Literature and research alludes to the difficulties with word-problem solving experienced by children with mathematics disabilities or dyscalculia. Since the MAiLgS programme proved to be effective in enhancing subtraction word-problem solving for some children with intellectual disabilities, a similar study with children with dyscalculia or mathematics disabilities warrants further exploration.

To the researcher's knowledge, this is the only study to address a mathematical construct using aided language stimulation, which is an augmented input strategy. Accordingly, given the positive effect derived from this study on mathematical word-problem solving, the use of aided language stimulation for other mathematical concepts such as teaching fractions, multiplication of single-digit numbers and the steps used in long division should be explored where supporting receptive language is central to conceptual development.

Fundamental to the success of the MAiLgS programme is the consistent implementation of the programme by the adult facilitator. Accordingly, for it to be an effective and feasible teaching strategy, teachers need to familiarise themselves with the programme. Exploring the ease with which this programme can be mastered by teachers seems justified.

7.6 Conclusion

This chapter summarised the conclusions derived from implementation of the MAiLgS programme and clinical implications that could be drawn from this study were discussed. The strengths and limitations of this study were explained and recommendations were made for future research that may be based on this study.

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Appendices

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Faculty of Humanities
Office of the Deputy Dean

Appendix A

Ethical Approval

1 July 2011

Dear Dr Dada,

Project:	**The effect of an aided input teaching tool on concept retention of mathematical operations for learners with moderate intellectual disabilities**
Researcher:	**TE Naudé**
Supervisor:	**Dr S Dada**
Department:	**Communication Pathology**
Reference number:	**10649922**

I am pleased to be able to tell you that the above application was **approved** by the **Postgraduate Committee** on 14 June 2011 and by the **Research Ethics Committee** on 30 June 2011. Data collection may therefore commence.

Please note that this approval is based on the assumption that the research will be carried out along the lines laid out in the proposal. Should the actual research depart significantly from the proposed research, it will be necessary to apply for a new research approval and ethical clearance.

The Committee requests you to convey this approval to the researcher.

We wish you success with the project.

Sincerely

Prof John Sharp
Chair: Postgraduate Committee &
Research Ethics Committee
Faculty of Humanities
UNIVERSITY OF PRETORIA
e-mail: john.sharp@up.ac.za

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Appendix AC

Feedback to parents on participant performance in the study

2014-02-10

Dear (*Parent' name*)

Thank You!

This letter serves to thank you for allowing (Child's name) to participate in my PhD study at (School's name)!

My study which was conducted at (*Schools' name*) is now complete. I am now pleased to be able to forward to you the results that (*Child's name*) achieved during the pre-assessment and intervention phases of the study. Please bear in mind that these results are not static and with further learning can be expected to change.

For the purposes of the study, (*Child's name*)'s identity is not revealed as each child is referred to as a participant instead. Accordingly, while her name appears on the attached pre-assessment report, this is for your information only. The report you are receiving will not be used in its current format in the study. Where her results are reported in the study, (*Child's name*) is referred to as 'Participant X' and (*School's name*) is referred to as ' The School.'

On completion of the study, I will make the final results available to you.

I hope that you will find the enclosed information useful.

Again, I wish to extend my sincere gratitude for your willingness to allow (*Child's name*) to assist me in completing this study.

<u>PhD PREASSESSMENT & INTERVENTION RESULTS</u>

Private and Confidential

I initially worked with each child individually and here with provide to you the results achieved by your child in the <u>standardized tools</u> used. Please note that the purpose of each tool is explained and your child's performance is reflected as an age equivalent score. This means that the score given provides an indication of the level on which your child is currently functioning; which can change with further learning.

<table>
<tr><th>Assessment tool</th><th>Purpose of assessment tool</th><th>Child's level of performance</th></tr>
<tr><td rowspan="3">Kaufmann Brief Intelligence Test – Second Edition (KBIT2)</td><td rowspan="3">The KBit2 is a brief measure of verbal and nonverbal intelligence. The Verbal scale measures crystalized (learning) ability and the Nonverbal scale measures fluid (independent) reasoning. The IQ composite score provides a descriptive indication of an individual's overall functioning.</td><td>Verbal: Below Average Range</td></tr>
<tr><td>Nonverbal: Lower Extreme Range</td></tr>
<tr><td>IQ Composite: Lower Extreme Range</td></tr>
<tr><td rowspan="2">Wechsler Individual Achievement Tet – Second Version (WIAT-II):</td><td>Mathematical Reasoning tests the ability to reason mathematically in order to solve word problems.</td><td>5 years 8 months</td></tr>
<tr><td>Numerical Operations test the ability to solve arithmetical problems using the four operations (=,-,x, ÷)</td><td>7 years 0 months</td></tr>
<tr><td>Peabody Vocabulary Test (PPVT)</td><td>The PPVT measures the receptive vocabulary of children based on the language of instruction thereby giving an indication of the vocabulary understood (but not necessarily used) by an individual.</td><td>7 years 5 months</td></tr>
</table>

During the intervention phase of my study, your child formed part of the small group who was exposed to subtraction word-problem solving using the mathematical aided language stimulation programme developed for this study.

Your child's results in the probes (tests) for each type of word-problem are presented below.

Word-problem type	Baseline phase (before teaching phase)	Intervention phase (during teaching phase)	Post-intervention phase (after teaching phase)	Maintenance phase (four weeks after teaching phase)
Change	2 / 6	23/30	50/60	17/18
Combine	1/48	5/30	28/30	16/18
Compare	0/78	23/30	not done	11/18

Please feel free to contact me should you have any queries.
Kind Regards,

Tracy Naudé
PhD Student at the University of Pretoria

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Appendix B
School principal consent

[redacted]

2014-01-06

[redacted]

The Principal of [redacted]

RE: REQUEST TO CONDUCT RESEARCH AT YOUR INSTITUTION

I am a Ph.D student at the Centre for Augmentative and Alternative Communication at the University of Pretoria. In partial fulfillment for the requirements of this degree, I am conducting a study with the aim of determining the effect of an aided language stimulation programme on mathematical word-problem solving for learners with intellectual disabilities. I hereby request permission to conduct the study of my proposed research study at your institution.

Rationale for the study:
Following trends in educational circles, a shift to focusing on the level of support required by individuals experiencing intellectual disabilities can open many doors in terms of educational opportunities for these learners. For this to happen, educators in classrooms catering for learners experiencing intellectual disabilities have the responsibility of enabling them to become as functional and independent as possible in the school environment.

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In part, access to the different learning areas including Mathematics is consequently required. Historically learners experiencing intellectual disabilities have generally received instruction in the basic mathematical skills; with more complex areas such as mathematical word-problem solving being perceived as too difficult for them to master. Experiencing difficulties with the understanding of the vocabulary used in mathematical word-problems, which appears to be a common experience amongst learners experiencing intellectual disabilities.

From the literature reviewed thus far, it would seem that support strategies used to teach learners with various forms of intellectual disabilities have involved oral explanations and demonstrations by educators, followed by concrete manipulation of apparatus by learners. Despite the success of such strategies, paucity in the literature consulted is evident with regard to teaching learners experiencing intellectual disabilities to solve mathematical word-problems using oral and visual modalities simultaneously to enhance understanding and thus the ability to act on what is taught.

Becoming more independent and competent in executing meaningful tasks is an important aspect not only of learning, but of daily functioning in society and strategies to promote these skills, therefore, need to be explored as a matter of urgency. Consequently, the purpose of this research is to determine the effect of using an aided language stimulation programme as a means to facilitate mathematical word-problem solving for learners experiencing intellectual disabilities, which will effectively enable them to employ these skills independently. The effect of this aided language stimulation programme will be explored through exposure to word-problems involving three types of subtraction.

What are the aims of this study?

The main aim of this study is to determine the effect of an aided language stimulation programme on mathematical word-problem solving for learners with intellectual disabilities.

The following sub-aims were formulated to attain the main aim:

1. To develop an aided language stimulation programme in keeping with the principles delineated by Goosens' (1989) to facilitate mathematical word-problem solving for subtraction.

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2. To obtain baseline data of accurate independent answers to mathematical subtraction word-problems *prior to* the aided language stimulation programme.
3. To implement the aided language stimulation programme.
4. To probe accurate independent answers to mathematical subtraction word-problems *during exposure to* the aided language stimulation programme.
5. To determine mathematical subtraction word-problem solving skills through the number of accurate independent answers to mathematical subtraction word-problems three weeks *after exposure* to the aided language stimulation programme.

What will be expected of you as an institution?

Upon approval of this request, you grant the researcher permission to conduct the study of the proposed research using the learners at your school.

This will entail providing the researcher with the names of the learners having intellectual disabilities to enable the researcher to identify possible participants. For this single subject research design approximately eight to 10 participants between the ages of eight and twelve years are required. It will also mean making available to the researcher the school records of the possible participants to verify their intellectual disability. Only relevant information regarding intellectual disability, diagnosis, age, gender and home language will be accessed by the researcher. All information will be treated as strictly confidential.

You would agree to assisting the researcher with disseminating and collecting the permission for parents of learners participating in this research given your relationship with and access to these parents. This would also enable you as the principal to keep record of which learners are to be involved.

You will be granting the researcher permission to use your premises as the pilot study site for the conduction of the research. This would include specifically allowing the researcher to use a classroom or suitable venue in which the study may be conducted. The tables and chairs in the venue would also be available for the duration of the study. You would grant the researcher permission to withdraw the learners from class to complete this study. This would include the pre-assessment of potential participants which will be done individually and require a total of three hours per learner. For the actual study which will be conducted in a group format, three

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forty five minutes each morning. Next, the intervention phase follows which includes a teaching component and an assessment component every day. During this time approximately sixty minutes will be used every morning (five days) for a period of three weeks. A maintenance assessment will finally be conducted three weeks following the last day of the intervention phase. This assessment will be conducted in one morning in the group format used previously and will require approximately thirty minutes. Furthermore, you will be granting the researcher permission to video-record the sessions conducted with the participants for the duration of the study. Video recordings form a part of the data collection process and will be treated as strictly confidential.

Will you as the institution have access to the research results?

The research results will be made available upon request following the completion of the project. The research data will be stored both as hard copy as well as in electronic format at the University of Pretoria for 15 years as part of the ethical requirements of the University. Results may also be shared with other professionals in article format and as a conference presentation.

Who can be contacted if you have any further questions?

Should you require any further information, you are welcome to contact the researcher on [redacted] or [redacted]

I trust that this letter has provided you with sufficient information to enable you to grant the researcher permission to conduct the proposed study at your institution. Please find attached; for your perusal copies of the letters and permission slips which will be disseminated to parents of learners who meet the selection criteria for this study. It would be appreciated if you would complete the attached reply slip as proof of permission being granted for this study to be conducted at your school.

Yours sincerely,

Tracy Naudé
Researcher

Dr. Shakila Dada
Supervisor

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REPLY SLIP:

PERMISSION TO CONDUCT THE MAIN STUDY OF THE PROPOSED RESEARCH AT THIS INSTITUTION

I, ________________________________, principal of (*School name*) hereby stipulate that:

1) I have received and read the request to conduct research at this institution from Tracy Naudé.

2) I understand that requirements for the completion of the study.

3) I agree to allow Tracy Naudé to conduct the study at (*School name*) in accordance with the requirements stipulated in the request.

Signed at ____________________________ on the ______ of _______________ 2014.

___________________________________ ___________________________________

Principal Tracy Naudé

School Stamp

REPLY SLIP:

CONSENT TO PARTICIPATE IN THE STUDY PROCESS

I, _______________________________, a teacher of (*School name*) hereby stipulate that:

1) I have received and read the request to conduct research at this institution from Tracy Naudé.

2) I understand that requirements for the completion of the study.

3) I agree to assist Tracy Naudé with the identification of potential participants for this study at (*School name*) in accordance with the requirements stipulated in the request.

Signed at ___________________________ on the ______ of ______________ 2014

____

Teacher

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Faculty of Humanities

Appendix C
Teacher consent

[redacted]

2014-01- 06

[redacted]

Teachers of [redacted]

RE: REQUEST TO CONDUCT RESEARCH AT YOUR INSTITUTION

I hereby wish to inform you that I have requested permission to conduct my proposed research study at your institution.

Research topic:

The effect of an aided language stimulation programme on mathematical word-problem solving for learners with intellectual disabilities.

Rationale for the study:

Following trends in educational circles, a shift to focusing on the level of support required by individuals experiencing intellectual disabilities can open many doors in terms of educational opportunities for these learners. For this to happen, educators in classrooms catering for learners experiencing intellectual disabilities have the responsibility of enabling them to become as functional and independent as possible in the school environment.

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In part, access to the different learning areas including Mathematics is consequently required. Historically learners experiencing intellectual disabilities have generally received instruction in the basic mathematical skills; with more complex areas such as mathematical word-problem solving being perceived as too difficult for them to master. Experiencing difficulties with the understanding of the vocabulary used in mathematical word-problems, which appears to be a common experience amongst learners experiencing intellectual disabilities, may have limited exposure to the more complex mathematical concepts for these learners even further.

From the literature reviewed thus far, it would seem that support strategies used to teach learners with various forms of intellectual disabilities have involved oral explanations and demonstrations by educators, followed by concrete manipulation of apparatus by learners. Despite the success of such strategies, paucity in the literature consulted is evident with regard to teaching learners experiencing intellectual disabilities to solve mathematical word-problems using oral and visual modalities simultaneously to enhance understanding and thus the ability to act on what is taught.

Becoming more independent and competent in executing meaningful tasks is an important aspect not only of learning, but of daily functioning in society and strategies to promote these skills, therefore, need to be explored as a matter of urgency. Consequently, the purpose of this research is to determine the effect of using an aided language stimulation programme as a means to facilitate mathematical word-problem solving for learners experiencing intellectual disabilities, which will effectively enable them to employ these skills independently. The effect of this aided language stimulation programme will be explored through exposure to word-problems involving three types of subtraction.

What are the aims of this study?

The main aim of this study is to determine the effect of an aided language stimulation programme on mathematical word-problem solving for learners with intellectual disabilities.

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The following sub-aims were formulated to attain the main aim:

1. To develop an aided language stimulation programme in keeping with the principles delineated by Goosens' (1989) to facilitate mathematical word-problem solving for subtraction.
2. To obtain baseline data of accurate independent answers to mathematical subtraction word-problems *prior to* the aided language stimulation programme.
3. To implement the aided language stimulation programme.
4. To probe accurate independent answers to mathematical subtraction word-problems *during exposure to* the aided language stimulation programme.
5. To determine mathematical subtraction word-problem solving skills through the number of accurate independent answers to mathematical subtraction word-problems three weeks *after exposure* to the aided language stimulation programme.

What will be expected of you as teacher?

Upon approval of this by the institution principal, you are requested to assist in the following way.

Complete a checklist to assist in determining which children meet the selection criteria for the study. For this single subject research design approximately eight to 10 participants aged between eight and twelve years are required. It will also mean making available to the researcher the school records of the possible participants to verify their biographical information and diagnoses. Only relevant information regarding intellectual disability, diagnosis, age, gender and home language will be accessed by the researcher. All information will be treated as strictly confidential.

You would also agree to allow children who meet the selection criteria for this study to leave the class during the sessions. This would include the pre-assessment of potential participants which will be done individually and require a total of three hours per learner. For the actual study which will be conducted in a group format, three consecutive mornings are used initially to conduct the baseline assessment which will take approximately forty five minutes each morning. Next, the intervention phase follows which includes a teaching component

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and an assessment component every day. During this time approximately seventy minutes will be used every morning (five days) for a period of three weeks. A maintenance assessment will finally be conducted three weeks following the last day of the intervention phase. This assessment will be conducted in one morning in the group format used previously and will require approximately thirty minutes.

Will you as the teacher have access to the research results?

The research results will be made available upon request following the completion of the project. The research data will be stored both as hard copy as well as in electronic format at the University of Pretoria for 15 years as part of the ethical requirements of the University. Results may also be shared with other professionals in article format and as a conference presentation.

Who can be contacted if you have any further questions?

Should you require any further information, you are welcome to contact the researcher on [redacted] or [redacted].

I trust that this letter has provided you with sufficient information to consent to participate in this study process. It would be appreciated if you would complete the attached reply slip as proof of consent to participate in the study process.

Yours sincerely,

TNaudé

Dada

Tracy Naudé — Researcher

Dr. Shakila Dada — Supervisor

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Official use
Participant nr

Please complete this form and return it by hand in the envelope provided to the principal's office at (School name).

Parental Informed Consent: Consent Reply Slip

Name of Participant: ____

Name of Parent: ____

Date: ______________________________

Project title:
The effect of aided language stimulation on mathematical word-problem solving for learners with intellectual disabilities.

Researcher: Tracy Naudé
PhD Student
University of Pretoria

Supervisor: Dr. Shakila Dada

I understand my rights as well as my child's rights as a participant. I understand the scope of this study and the way in which it will be conducted.

I hereby (*please tick to indicate consent*):

☐ **Voluntarily declare my consent for my child to participate in this study.**

Accordingly, I consent to the following research conditions:

☐ Access to my child's school records to provide information regarding my child's name, age, home language, pre-existing conditions, vision and hearing competency.

☐ The use of video recordings of the research sessions of the group of which my child will form a part. I understand that these recordings will be used for data collection and analysis purposes and may be used as part of a presentation of the research findings at conferences.

☐ Would like to receive written feedback regarding the pre-assessment results obtained by my child.

☐ Would like to get feedback about the results of this study.

OR

☐ **Declare that my child may not participate in this study.**

Signature of Parent of Participant

Date

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Faculty of Humanities

13 January 2014

Appendix D
Parent consent

PARENTAL INFORMED CONSENT LETTER

THE EFFECT OF AN AIDED LANGUAGE STIMULATION PROGRAMME ON MATHEMATICAL WORD-PROBLEM SOLVING FOR LEARNERS WITH INTELLECTUAL DISABILITIES

Background

Following trends in educational circles, a shift to focusing on the level of support required by individuals experiencing intellectual disabilities can open many doors in terms of educational opportunities for these learners. For this to happen, educators in classrooms catering for learners experiencing intellectual disabilities have the responsibility of enabling them to become as functional and independent as possible in the school environment.

In part, access to the different learning areas including Mathematics is consequently required. Historically learners experiencing intellectual disabilities have generally received instruction in the basic mathematical skills; with more complex areas such as mathematical word-problem solving being perceived as too difficult for them to master. Experiencing difficulties with the understanding of the vocabulary used in mathematical word-problems, which appears to be a common experience amongst learners experiencing intellectual disabilities, may have limited exposure to the more complex mathematical concepts for these learners even further.

From the literature reviewed thus far, it would seem that support strategies used to teach learners with various forms of intellectual disabilities have involved oral explanations and demonstrations by educators, followed by concrete manipulation of apparatus by learners. Despite the success of such strategies, paucity in the literature consulted is evident with regard to teaching learners experiencing intellectual disabilities to solve mathematical word-problems using oral and visual modalities simultaneously to enhance understanding and thus the ability to act on what is taught.

Becoming more independent and competent in executing meaningful tasks is an important aspect not only of learning, but of daily functioning in society and strategies to promote these skills, therefore,

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need to be explored as a matter of urgency. Consequently, the purpose of this research is to determine the effect of using an aided language stimulation programme as a means to facilitate mathematical word-problem solving for learners experiencing intellectual disabilities, which will effectively enable them to employ these skills independently. The effect of this aided language stimulation programme will be explored through exposure to word-problems involving three types of subtraction.

What are the aims of this study?

The main aim of this study is to determine the effect of an aided language stimulation programme on mathematical word-problem solving for learners with intellectual disabilities.

The following sub-aims were formulated to attain the main aim:

1. To develop an aided language stimulation programme in keeping with the principles delineated by Goosens' (1989) to facilitate mathematical word-problem solving for subtraction.
2. To obtain baseline data of accurate independent answers to mathematical subtraction word-problems *prior to* the aided language stimulation programme.
3. To implement the aided language stimulation programme.
4. To probe accurate independent answers to mathematical subtraction word-problems *during exposure to* the aided language stimulation programme.
5. To determine mathematical subtraction word-problem solving skills through the number of accurate independent answers to mathematical subtraction word-problems three weeks *after exposure* to the aided language stimulation programme.

Why participation is important?

Participation in this research project will have no direct benefit to you. However, your child as a participant may benefit from being exposed to the aided language stimulation programme and may contribute to the development of more successful teaching strategies and tools which may benefit more learners experiencing intellectual disabilities.

What is expected of you as a participant?

To enable your child's participation in this study you are requested to complete the *Parental Informed Consent Slip* and your child is requested to complete the *Learner Assent* form. The learner assent form will be completed together with the researcher, during the individual session with your child, on the first day that the study begins at the school your child attends. No further participation will be required of you as the parent for this study. However, it would be greatly appreciated if you

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would agree for your child to participate in this study, as his/her participation is highly valued.

Will you experience any risk or inconvenience during this study?

Since you as the parent will not be directly involved in the study, you should not experience any risk what so ever. Inconvenience to you will be limited to completing the Informed Consent Slip and returning it to the researcher.

What are your rights as a parent of a participant in this study?

You may at any given time throughout this study decide to withdraw your child as participant. Should you decide to withdraw, your decision to do so will in no way penalize you or your child.

Will you have access to the research results?

The research results will be made available upon request following the completion of the project. The research data will be stored both as hard copy as well as in electronic format at the *Department of Library Services* at the University of Pretoria for 15 years.

Who can be contacted if you have any further questions?

Should you require any further information, you are welcome to contact the researcher on [redacted] or [redacted].

I trust that this letter has provided you with sufficient information to consent to participate in this study process. It would be appreciated if you would complete the attached reply slip as proof of consent to participate in the study process.

Kindly e-mail the researcher or deliver by hand, your Informed Consent form.

Thank you in advance for your time and co-operation!

Yours sincerely,

Tracy Naudé
Researcher

Dr. Shakila Dada
Supervisor

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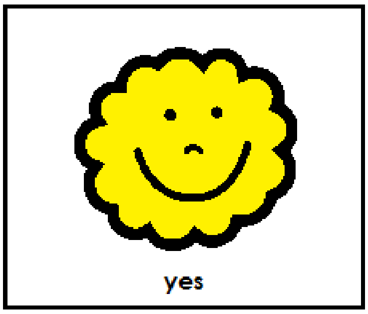
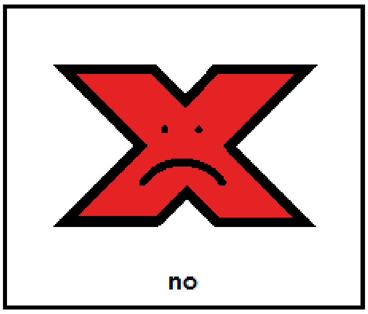
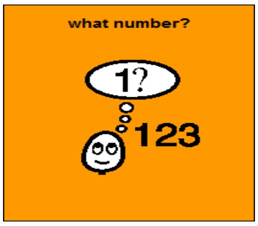
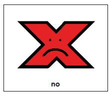
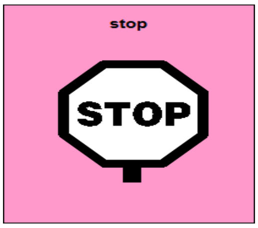
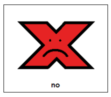
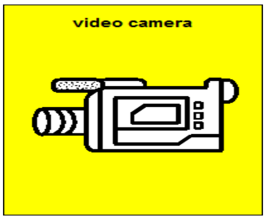
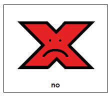
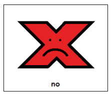
Appendix E
Participant Assent

Participant Number	

I am going to ask you some questions and I would like you to answer 'yes' or 'no'.

For yes I would like you to mark this picture:	For no I would like you to mark this picture:
	

Questions			
	Would you please help me to learn more about how to do story sums?		
	Do you understand that you can stop when you want to?		
	Is it okay with you if we video tape what we are doing?		
	Do you have any questions?		

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Appendix F
Learner Screening Tool by Teachers (LeSTE)

LEARNER SCREENING TOOL BY TEACHERS (LeSTE)

Learner Name: ________________________________

Participant Nr.	

Date of Birth: ____________________

Age: _____ **years** ____ **month/s**

Gender: ____

Primary Diagnosis: ____

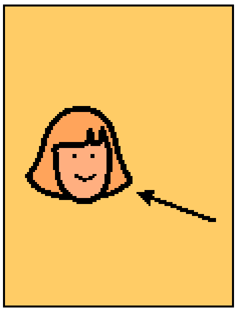
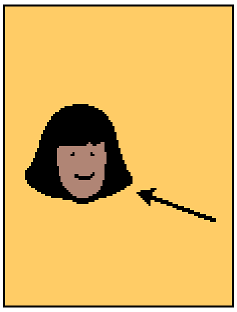
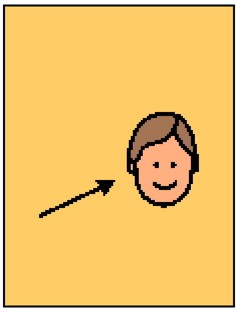
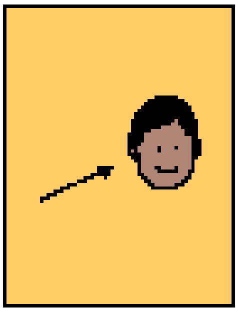
For each of the following questions, please indicate (✓) this learner's ability in each of the areas listed.

AREAS		YES	NO	*Admin Use*
Vision	1. Are you aware of any visual problems that affect this learner's ability to learn?			
	2. Does the learner wear glasses or contact lenses?			
Hearing	3. Are you aware of any hearing problems that affect this learner's ability to learn?			
	4. Does the learner wear a hearing aid?			
	5. Does the learner respond when called by a person not facing him/her?			
Motor Skills	6. Does the learner have any physical disabilities that affect his/her ability to use his/her hands?			M N
	7. Can the learner hold a piece of paper or cardboard in his/her hands?			M N
	8. Can the learner pick up small objects the size of a 5c coin with one or both hands?			M N
	9. Can the learner control a pencil / crayon to write?			M N
Cognitive	10. Can the learner identify visual objects (e.g. pictures) in the front of the classroom from his/her desk?			M N
	11. Can the learner identify pictures, symbols or words in a book s/he is holding?			M N
	12. Can the learner follow instructions?			M N
	13. Can the learner listen to an explanation without interrupting?			M N
	14. Can the learner concentrate on a task for 20 minutes?			M N
LoLT	15. Does the learner understand English as the Language of Learning and Teaching?			M N
	16. Can the learner use English as the Language of Learning and Teaching to communicate?			M N
PCS	17. Has the learner been exposed to Picture Communication Symbols (Boardmaker) at school?			M N
	18. Can the learner recognize any Picture Communication Symbols used in lessons?			M N
				M N

Learner Screening Tool by Educators completed by: ______________________________

Appendix G

PCS symbols presented to Grade R peer panel

1	2	3	4
			
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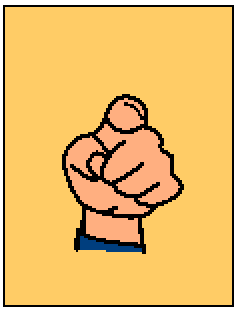	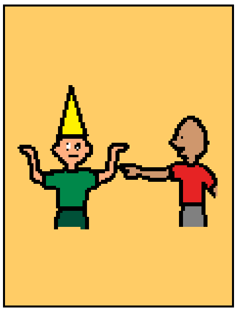		
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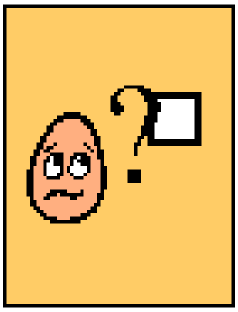	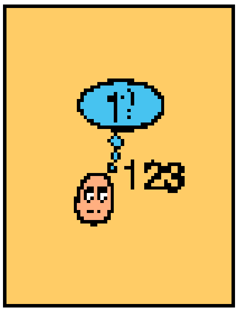		

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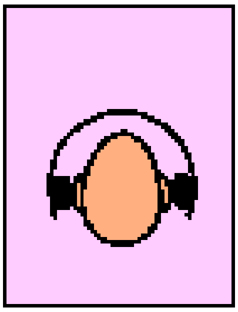	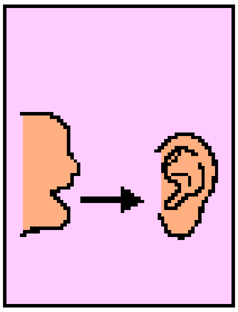	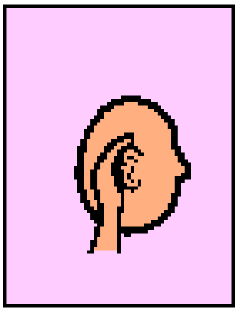	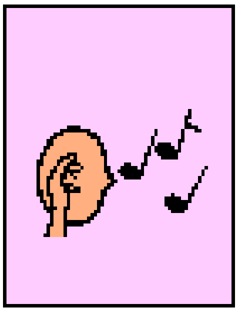
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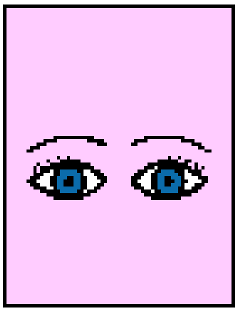	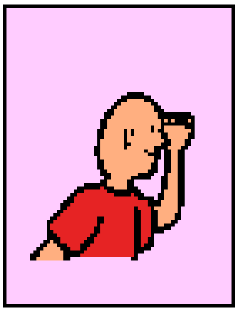	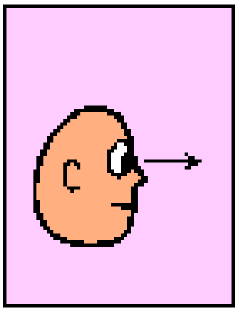	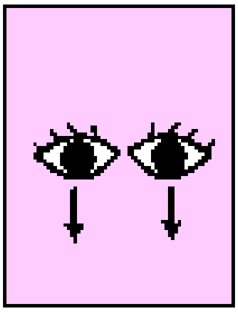
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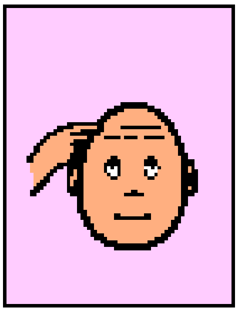	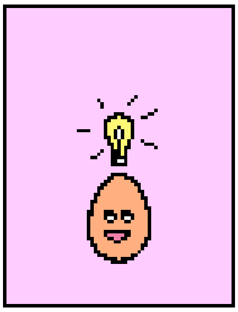	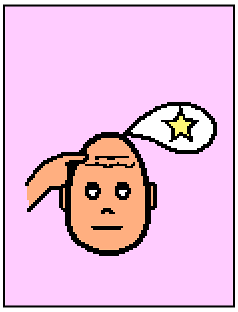	
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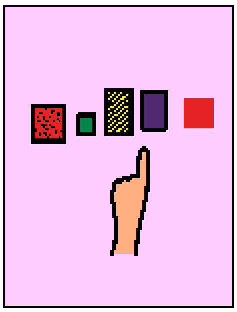	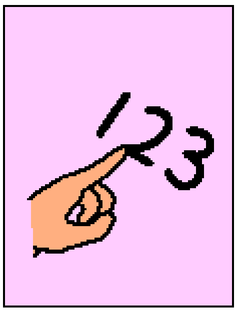		

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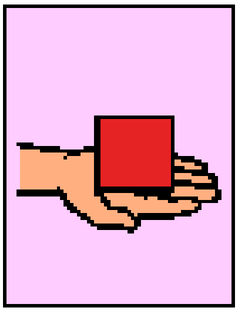	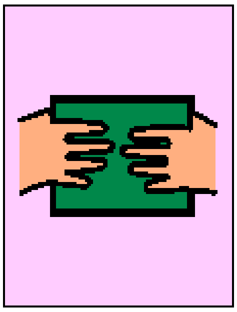		
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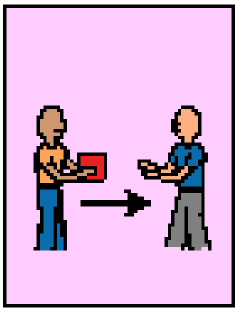	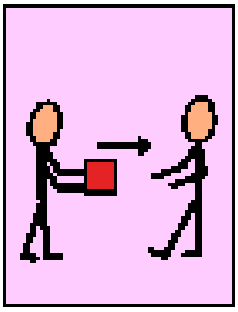	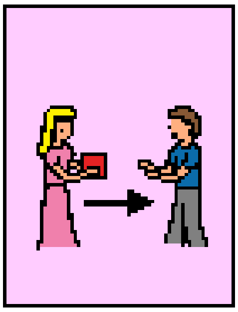	
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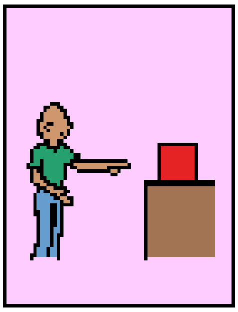	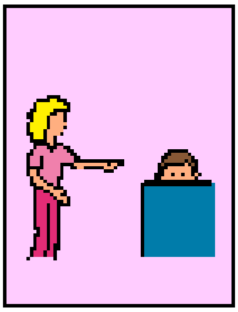	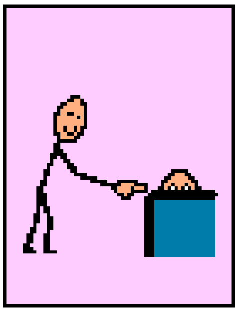	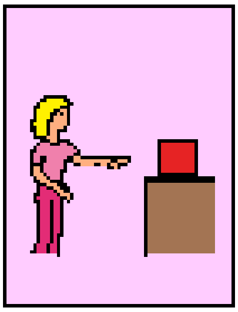
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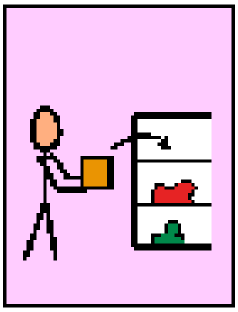	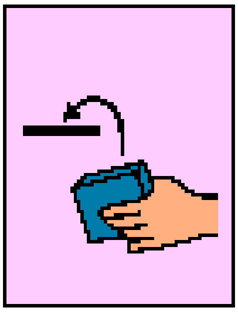	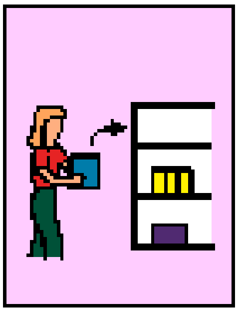	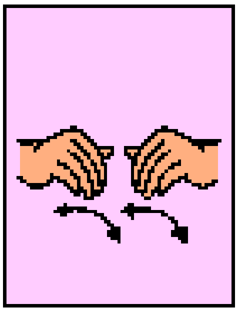

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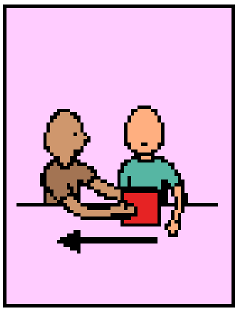	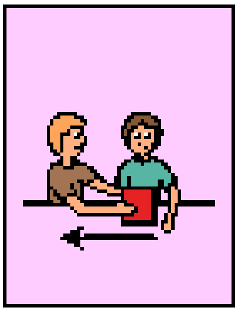	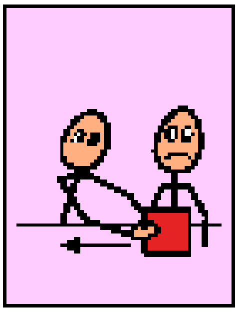	
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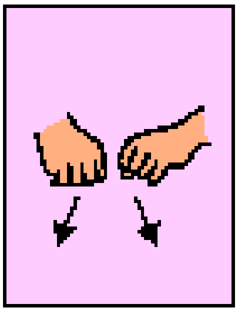	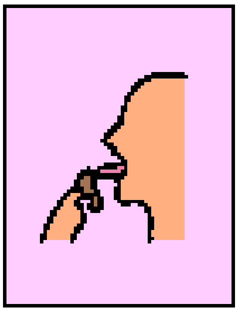		
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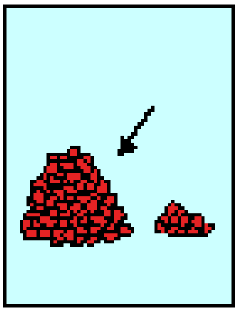	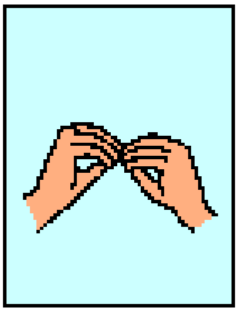		
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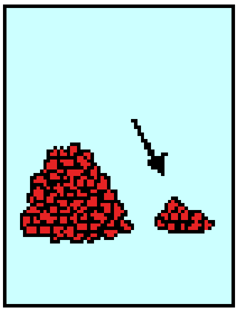	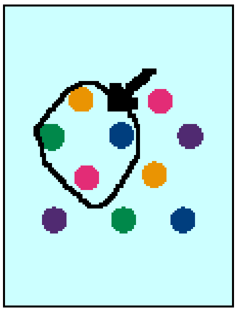	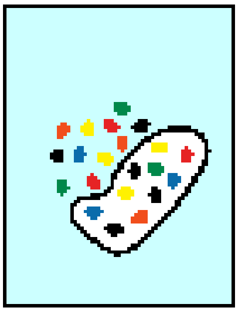	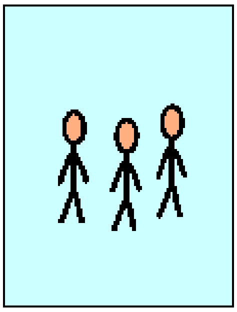

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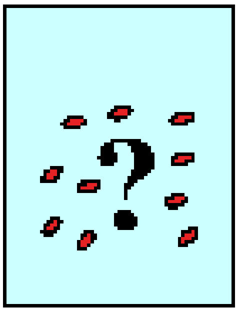		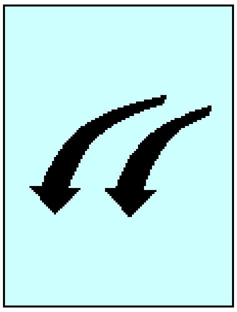	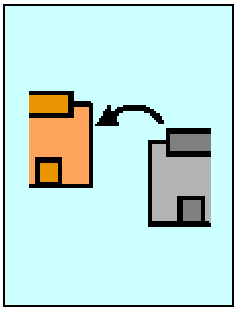
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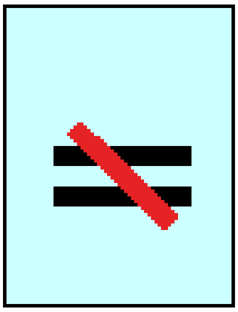	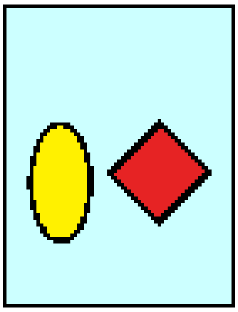	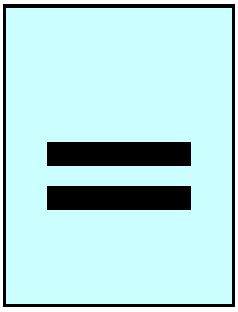	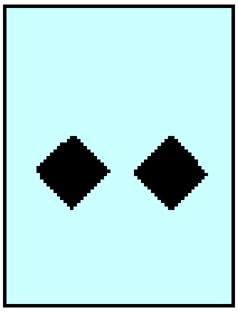
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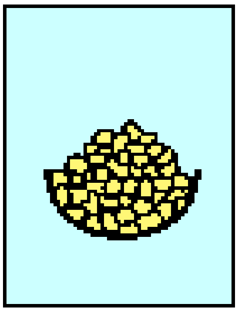	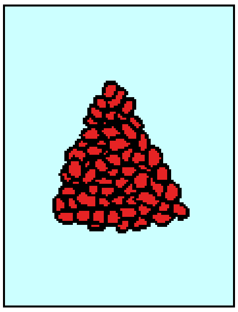	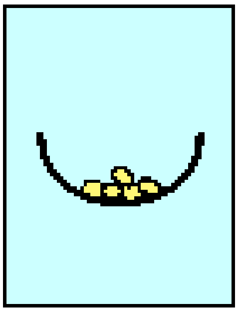	
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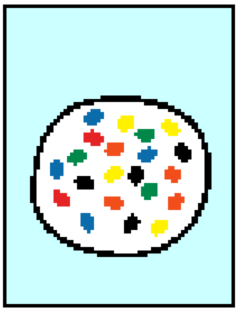	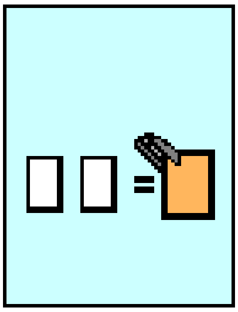	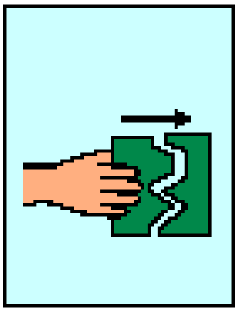	

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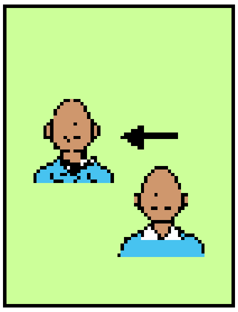	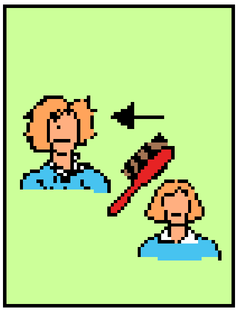	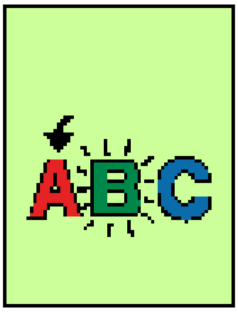	
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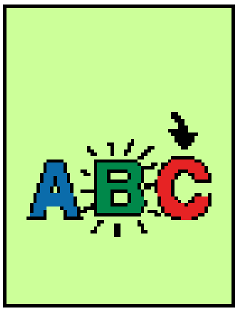	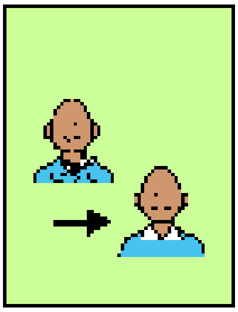	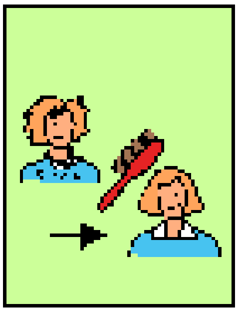	
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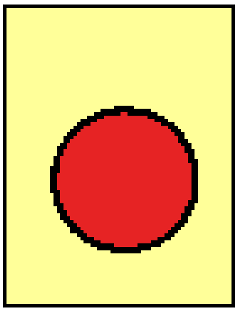	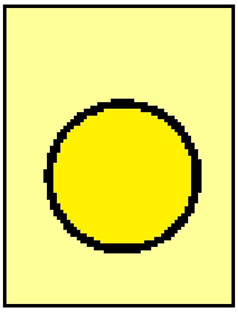	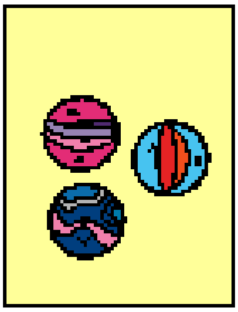	
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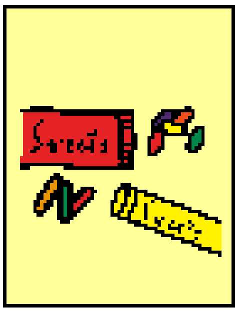	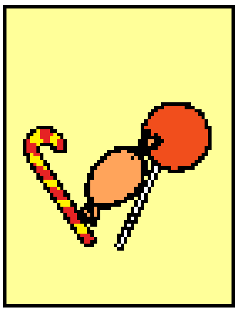	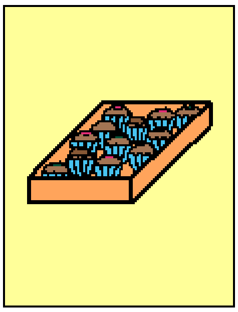	

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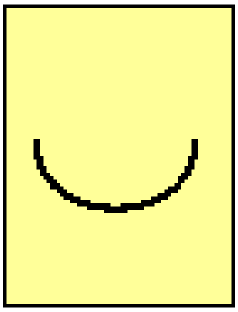	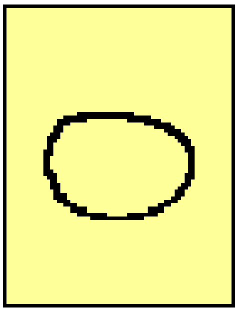	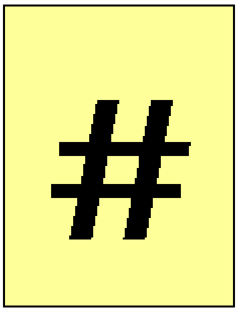	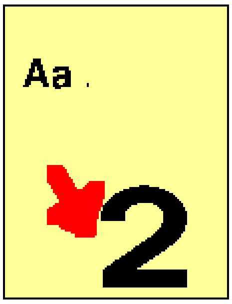
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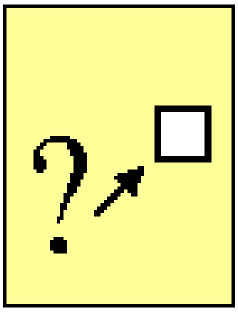	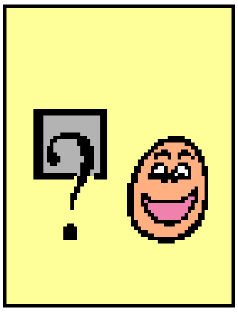	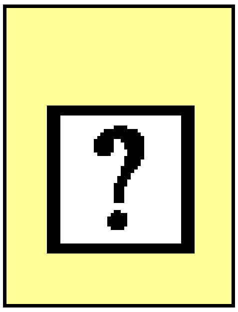	
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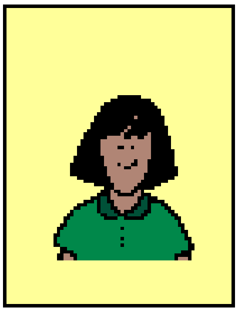	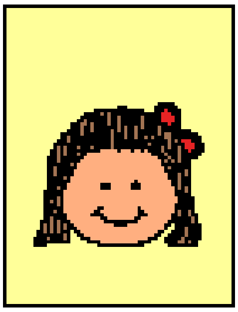	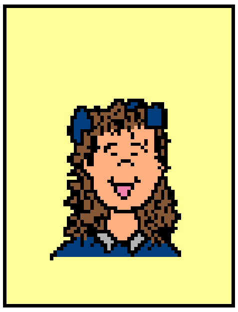	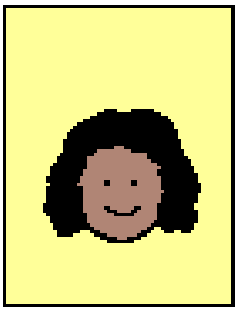
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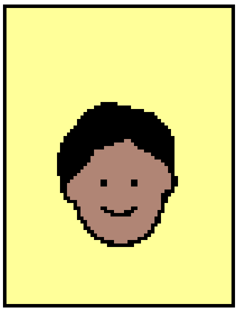	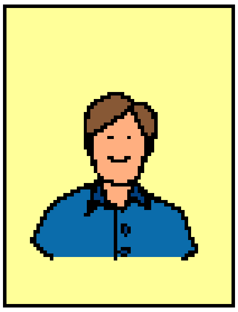	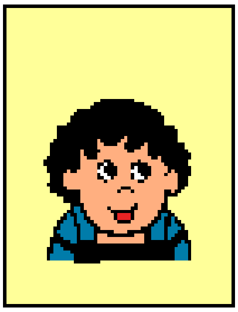	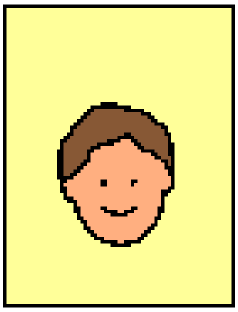

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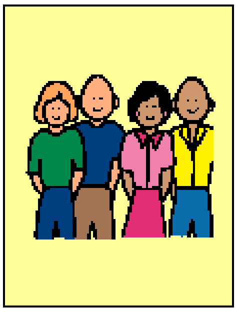
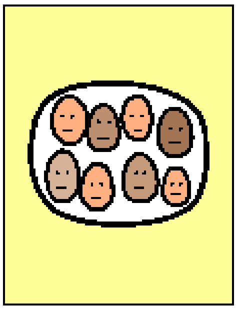
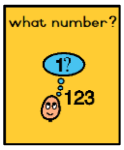
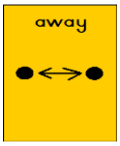
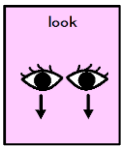
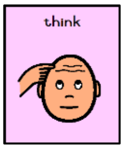
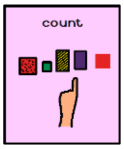
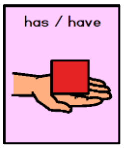
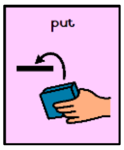
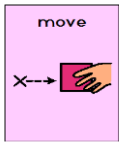
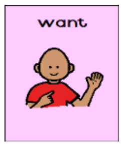
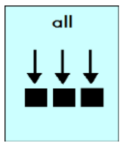
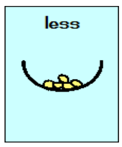
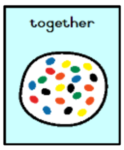
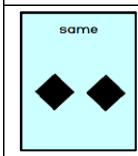
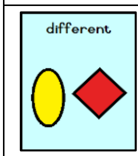
			

PCS symbol Identification Test **Appendix I** Participant Nr.: ________

Symbol	Trial 1	Trial 2	Trial3	Trial 4	%✓
					
					
					
					
					
					
					
					
					
					
					
					

Symbol	Trial 1	Trial 2	Trial 3	Trial 4	%✓
					
					
					
					
					
					
					
					
					
					
					
					

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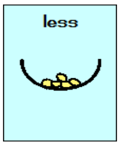
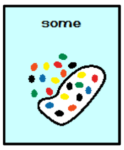
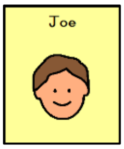
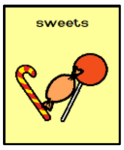
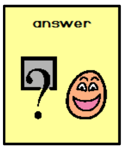
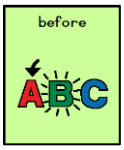
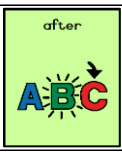
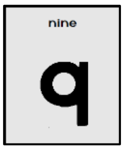
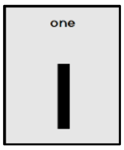
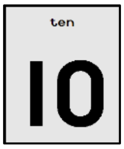
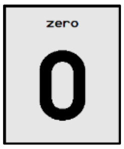
Symbol	Trial 1	Trial 2	Trial 3	Trial 4	%✓
					
					
					
					
					
					
					
					
					
					
					
					

Symbol	Trial 1	Trial 2	Trial 3	Trial 4	%✓
					
					
					
					
					
					
					
					
					
					
					

TOTAL SCORE: _______ / 47

PERCENTAGE CORRECT: ______%

Appendix J

Informal Counting Test

INFORMAL COUNTING TEST **Participant Number: ____**

Participant must count out the given number of counters.

NUMBER	CCO*	✓	X
3			
5			
2			
7			
9			
1			
4			
8			
6			
10			
TOTALS			

**CCO = Counters counted out*

Appendix K
MAiLgS programme script: Change type

Mathematical Aided Language Stimulation (MAiLgS) Programme Script

Change (Change unknown)

Hello everyone! It's really nice to be here with all of you today! Last time you all worked on your own to solve the story sums, but today, we will work them out together.

*Here is a board I am going to use to help me tell you the story sums (*point to facilitator board*).*

*When we do the story sums I will use these pictures, coloured boxes and counters to help us work out the answers (*show PCS symbols, red and purple calculation mats and counters*).*

*Each day you will get an answer sheet like this (*show*) and we will circle our answers on here too.*

*Now, I am going to tell you a story sum. Then we are going to work out the answer for the story sum. Are you all ready? (*Wait for acknowledgement from participants*).*

The first story sum goes like this…

ZINZI HAS | ❤ 7 | 8 | 5 | ✂ 9 | ⇨ 10 | 👁 6 | SWEETS.

Then, she GIVES SOME to JOE.

NOW ZINZI HAS | ❤ 2 | 6 | 4 | ✂ 5 | ⇨ 8 | 👁 0 | SWEETS.

HOW MANY SWEETS does ZINZI GIVE to JOE?

to work out this ANSWER, we must GIVE ZINZI her

| ❤ 7 | 8 | 5 | ✂ 9 | ⇨ 10 | 👁 6 | SWEETS.

we PUT them here on her red mat.

let's COUNT ZINZI'S SWEETS…

there, now ZINZI HAS her | ❤ 7 | 8 | 5 | ✂ 9 | ⇨ 10 | 👁 6 |

SWEETS.

but LOOK, JOE HAS no SWEETS yet.

He HAS NOTHING on his purple mat.

So ZINZI is kind, she will SHARE with JOE.

ZINZI will GIVE SOME SWEETS to JOE,

but we DON'T KNOW HOW MANY SWEETS ZINZI GIVES to JOE,

because she only says that she will GIVE him SOME.

ZINZI TAKES SOME SWEETS and PUTS them on JOE'S mat,

but she does not tell us HOW MANY she PUTS there!

but we can FIND the ANSWER.

we must THINK OF HOW MANY ZINZI HAS AFTER she GIVES SOME SWEETS to JOE.

remember, ZINZI HAS ❤ 2 🏍 6 🐈 4 ✂ 5 ⇨ 8 👁 0

SWEETS AFTER she GIVES SOME to JOE.

So, AFTER ZINZI GIVES JOE SOME SWEETS,

she must KEEP ❤ 2 🏍 6 🐈 4 ✂ 5 ⇨ 8 👁 0 *SWEETS for herself.*

We KEEP ❤ 2 🏍 6 🐈 4 ✂ 5 ⇨ 8 👁 0 *SWEETS for ZINZI, so we KEEP these for her.*

The other SWEETS are for JOE.

So we TAKE ALL those SWEETS and MOVE them to JOE'S mat.

Now we'll COUNT HOW MANY SWEETS JOE HAS...

(count) ❤ 5 🏍 2 🐈 1 ✂ 4 ⇨ 2 👁 6

LOOK, now JOE HAS SWEETS AFTER ZINZI GIVES him SOME SWEETS.

So WHAT NUMBER is our ANSWER for HOW MANY SWEETS ZINZI GIVES to JOE?

Yes, the ANSWER is | ♥ 5 🏍 2 🐈 1 ✂ 4 ⇨ 2 👁 6 |.

So we are going to circle NUMBER | ♥ 5 🏍 2 🐈 1 ✂ 4 ⇨ 2 👁 6 | ***next to the*** | ♥ 🏍 🐈 ✂ ⇨ 👁 | ***the answer sheet.***

Well done! Let's try another one!

Repeat the word-problem once if answers are incorrect. *Uh-oh, this story sum is a bit tricky, so let's try it again.*

After completion of the word-problem … *Let's LOOK at another story sum.*
After completion of final story sum participants get a 5 minute break. They then return to complete the intervention probes.

Appendix L
MAiLgS programme script: Combine type

Combine (Total unknown)

Hello everyone! I hope you all enjoyed the story sums we did last week. You all worked so hard to help me, thank you! Today we are going to do other stories together.

*We will still use this board to help me tell you the story (*point to facilitator board*).*

*When we do these stories I will use these counters and coloured boxes to help us find the answers (*show counters and red and purple calculation mats on facilitator board*).*

When we find the answers for each story sum you are going to draw a circle around the answer on you answer sheet. I will tell you which picture to draw next to.

Now, I am going to tell you a new story sum and we are going to find the answer for it.

*Are you ready? (*Wait for confirmation from participants*).*

ZINZI and JOE HAVE | ■9 🚍8 ✍ 5 ✓9 👄10 ☜6 |

SWEETS TOGETHER.

ZINZI HAS | ■1 🚍3 ✍ 2 ✓3 👄1 ☜5 | *SWEET/S.*

HOW MANY SWEETS does JOE HAVE?

NOW we DON'T KNOW HOW MANY SWEETS JOE HAS.

So to FIND that ANSWER, we must let ZINZI and JOE

HAVE | ■9 🚍8 ✍ 5 ✓9 👄10 ☜6 | *SWEETS TOGETHER.*

ZINZI and JOE PUT their SWEETS TOGETHER like that.

Right now ZINZI HAS NOTHING and JOE also HAS

NOTHING. | ■1 🚍3 ✍ 2 ✓3 👄1 ☜5 |

But remember, ZINZI must HAVE

| ■1 🚍3 ✍ 2 ✓3 👄1 ☜5 | *SWEETS.*

So we must PUT those SWEETS here on her red mat.

That means we have to TAKE ZINZI'S SWEETS AWAY here and PUT them here.

Lucky ZINZI she HAS SOME SWEETS now!

Now LOOK, there are LESS SWEETS here.

But what about poor JOE? JOE still HAS NOTHING.

I'm sure that he would also like SOME SWEETS.

Wait a bit, LOOK here, we can GIVE SOME SWEETS to JOE!

He can HAVE ALL these SWEETS because ZINZI already has her SWEETS.

Yay! JOE can HAVE SWEETS too!

Now we should COUNT HOW MANY SWEETS we can GIVE to JOE.

Now we KNOW that JOE HAS ■8 5 3 ✓6 9 1 ***SWEETS.***

So WHAT NUMBER must we FIND and circle?

We must circle number ■8 5 3 ✓6 9 1

After completion of problem…………Repeat the problem once if answers are incorrect otherwise go to the next problem. After completion of final story sum participants get a 5 minute break. They then return to complete the intervention probes.

Appendix M
MAiLgS programme script: Compare type

Compare (Difference unknown)

Good morning everyone! I am so happy that you are all helping me with the stories I have. So today I am going to tell you some different stories.

*We are going to use this board to help me tell you the stories again, just like we did before (*point to facilitator board*).*

*When we do these stories I will also use these counters and coloured boxes to help us find the answers again (*show counters and red and purple calculation mats on facilitator board*).*

You have a new answer sheet for today and we will circle our answers as we go along.

Let's see what the first story is.

ZINZI HAS | ♦ 7 🚑 10 🐈 3 ✋ 4 ? 8 ✎ 5 | ***SWEETS.***

JOE HAS | ♦ 3 🚑 4 🐈 2 ✋ 1 ? 3 ✎ 3 | ***SWEETS.***

HOW MANY SWEETS does JOE HAVE LESS than ZINZI?

To work out this ANSWER, we must GIVE ZINZI her

| ♦ 7 🚑 10 🐈 3 ✋ 4 ? 8 ✎ | ***SWEETS.***

Let's COUNT ZINZI'S SWEETS and PUT them here on her red mat.

There, now ZINZI HAS her | ♦ 7 🚑 10 🐈 3 ✋ 4 ? 8 ✎ 5 | ***SWEETS.***

And JOE HAS | ♦ 3 🚑 4 🐈 2 ✋ 1 ? 3 ✎ 3 | ***SWEETS.***

Let's COUNT JOE'S SWEETS and PUT them here on his purple mat.

There, now JOE HAS his | ♦ 3 🚑 4 🐈 2 ✋ 1 ? 3 ✎ | ***SWEETS.***

Now LOOK, ZINZI and JOE don't HAVE the SAME NUMBER of SWEETS.

Their NUMBER of SWEETS is DIFFERENT.

ZINZI HAS MORE SWEETS than JOE.

ZINZI HAS MANY SWEETS because she HAS

♦ 7	🚑 10	🐈 3	✋ 4	? 8	✎

So JOE HAS LESS SWEETS than ZINZI.

JOE HAS FEW SWEETS because he HAS

♦ 3	🚑 4	🐈 2	✋ 1	? 3	✎

SWEETS.

To FIND HOW MANY SWEETS JOE HAS LESS than ZINZI,

We must LOOK HOW MANY of their SWEETS are the SAME.

We must see which SWEETS match.

So, these SWEETS match, these SWEETS match…ALL these SWEETS to here match.

But LOOK here, these SWEETS for ZINZI don't HAVE SWEETS by JOE to match.

So that means for ALL these SWEETS JOE HAS LESS than ZINZI because he does not HAVE enough SWEETS to match ZINZI'S.

AFTER we match the SAME SWEETS, we can COUNT HOW MANY SWEETS JOE does not HAVE to match the SAME NUMBER as ZINZI'S.

Those are the SWEETS that JOE HAS LESS than ZINZI. let's COUNT them…

So JOE HAS ♦ 4 🚑 6 🐈 1 ✋ 3 ? 5 ✎ 2 *LESS SWEETS than ZINZI.*

So our ANSWER for HOW MANY SWEETS JOE HAS LESS than ZINZI is ♦ 4 🚑 6 🐈 1 ✋ 3 ? 5 ✎ 2.

So we are going to circle NUMBER ♦ 4 🚑 6 🐈 1 ✋ 3 ? 5 ✎ 2 *next to the* ♦ 🚑 🐈 ✋ ? ✎ *the answer sheet.*

Well done! Let's try another one!

After completion of problem…………Repeat the problem once if answers are incorrect otherwise go to the next problem. After completion of final story sum participants get a 5 minute break. They then return to complete the intervention probes.

Appendix N
Baseline probe scripts

Baseline Probes Script Day One

Good morning everyone! Last week I got to work with each one of you on your own and today is an exciting day because we get to work together in this group. So I am going to ask you to work out some story sum answers for a while and when we are done you will go back to class. Don't worry about your school work, your teacher won't let you miss out on anything the rest of your class does while you are helping me here.

*When we do the story sums I want you to work by yourself and not look at anyone else's work. In front of you is a board that has red and purple blocks with pictures of children. You also have twenty white counters in this little box. If you want to, you can use them to help you work out the answers to the story sums. You also have a pencil and a sheet of paper with coloured pictures and numbers on (*show*).*

I am going to read a story sum to you and then I will read it again. After that I will give you some time to work out the answers for the story sums. When you know the answer you will circle it on the answer sheet. The story sums are all about two children, their names are Zinzi and Joe. We are first going to do the story sum for the black book. So I want you to work out the answer for this story sum please…

*Zinzi has three sweets, then she gives one sweet to Joe. How many sweets does Zinzi have now? Listen again…(*repeat*).*

*Now, I want you to find the answer next to the black book and circle it (*check that participants circle a number*).*

*(*Assist participants with circling a number next to the example block symbolized by the black book where necessary*). Well done everyone!*

*Now we are going to do the next story sums in the same way. I will read the story sum two times. When you have worked out the answer, circle it on your page next to picture I tell you. Remember, don't tell me the answer, you just circle it because your answer is your secret! If you make a mistake please put up your hand and I will come and help you. Do any of you have questions? (*answer any questions raised*).*

*Right everyone let's do the next story sums… (*conduct each word problem as described for the example item*).*

✓	*Zinzi and Joe have 9 sweets together. Zinzi has 3 sweets. How many sweets does Joe have?*	**6**
♥	*Zinzi has 7 sweets. Then she gives some to Joe. Now Zinzi has 2 sweets. How many sweets does Zinzi give to Joe?*	**5**
	Zinzi has 5 sweets. Joe has 3 sweets. How many sweets does Joe have less than Zinzi?	**2**
	Zinzi has 8 sweets. Then she gives some to Joe. Now Zinzi has 6 sweets. How many sweets does Zinzi give to Joe?	**2**
	Zinzi and Joe have 8 sweets together. Zinzi has 3 sweets. How many sweets does Joe have?	**5**
	Zinzi has 10 sweets. Then she gives some to Joe. Now Zinzi has 8 sweets. How many sweets does Zinzi give to Joe?	**2**
?	*Zinzi has 8 sweets. Joe has 1 sweet. How many sweets does Joe have less than Zinzi?*	**7**
	Zinzi and Joe have 5 sweets together. Zinzi has 2 sweets. How many sweets does Joe have?	**3**
	Zinzi has 3 sweets. Joe has 2 sweets. How many sweets does Joe have less than Zinzi?	**1**
	Zinzi and Joe have 10 sweets together. Zinzi has 1 sweet. How many sweets does Joe have?	**9**
♦	*Zinzi has 7 sweets. Joe has 3 sweets. How many sweets does Joe have less than Zinzi?*	**4**
■	*Zinzi and Joe have 9 sweets together. Zinzi has 1 sweet. How many sweets does Joe have?*	**8**
	Zinzi has 6 sweets. Then she gives some to Joe. Now Zinzi has 0 sweets. How many sweets does Zinzi give to Joe?	**6**
	Zinzi has 10 sweets. Joe has 4 sweets. How many sweets does Joe have less than Zinzi?	**6**
	Zinzi has 9 sweets. Then she gives some to Joe. Now Zinzi has 5 sweets. How many sweets does Zinzi give to Joe?	**4**
	Zinzi and Joe have 6 sweets together. Zinzi has 5 sweets. How many sweets does Joe have?	**1**
	Zinzi has 5 sweets. Then she gives some to Joe. Now Zinzi has 4 sweets. How many sweets does Zinzi give to Joe?	**1**
	Zinzi has 4 sweets. Joe has 1 sweet. How many sweets does Joe have less than Zinzi?	**3**

(Wait for all participants to complete last story sum).

Everyone is finished now so please put your pencils down on your table.

*Now put your counters back inside the little box. (*Let participants do this*).*

Thank you all so much, you may stand up now and push your chairs in.

*I'll see you all tomorrow again, enjoy the rest of your day! As you go out to class you may each have a sticker for all your hard work! (*let participants lead out and give each one a sticker as they leave*).*

Baseline Probes Script Day Two

Hello everyone! Nice to see you all again today. You are going to work out some story sum answers again, just like we did yesterday.

*Remember to work by yourself and don't look at anyone else's work. You still have the board with red and purple blocks and pictures of children and ten white counters in the bottle to work out the answers. Today you have a new answer sheet with coloured pictures and numbers (*show*) to circle your answers with the pencil.*

*I am going to read a story sum to you two times like yesterday. Then you must please work out the answer and circle it on the answer sheet. Remember, you don't tell me the answer; you just circle it because your answer is your secret! If you make a mistake please put up your hand and I will come and help you. Do any of you have questions? (*answer any questions raised*).*

So now let's do these….Now we are going to do the next story sums in the same way. I will read the story sum two times. When you have worked out the answer, circle it on your page next to picture I tell you (conduct each word problem as described for the example item).

	Zinzi has 3 sweets. Joe has 2 sweets. How many sweets does Joe have less than Zinzi?	**1**
	Zinzi and Joe have 5 sweets together. Zinzi has 2 sweets. How many sweets does Joe have?	**3**
	Zinzi has 9 sweets. Then she gives some to Joe. Now Zinzi has 5 sweets. How many sweets does Zinzi give to Joe?	**4**
	Zinzi has 10 sweets. Joe has 4 sweets. How many sweets does Joe have less than Zinzi?	**6**
	Zinzi and Joe have 10 sweets together. Zinzi has 1 sweet. How many sweets does Joe have?	**9**
	Zinzi has 5 sweets. Joe has 3 sweets. How many sweets does Joe have less than Zinzi?	**2**

	Zinzi and Joe have 6 sweets together. Zinzi has 5 sweets. How many sweets does Joe have?	**1**
	Zinzi has 7 sweets. Then she gives some to Joe. Now Zinzi has 2 sweets. How many sweets does Zinzi give to Joe?	**5**
	Zinzi and Joe have 8 sweets together. Zinzi has 3 sweets. How many sweets does Joe have?	**5**
	Zinzi has 6 sweets. Then she gives some to Joe. Now Zinzi has 0 sweets. How many sweets does Zinzi give to Joe?	**6**
?	*Zinzi has 8 sweets. Joe has 1 sweet. How many sweets does Joe have less than Zinzi?*	**7**
✓	*Zinzi and Joe have 9 sweets together. Zinzi has 3 sweets. How many sweets does Joe have?*	**6**
	Zinzi has 5 sweets. Then she gives some to Joe. Now Zinzi has 4 sweets. How many sweets does Zinzi give to Joe?	**1**
⇨	*Zinzi has 10 sweets. Then she gives some to Joe. Now Zinzi has 8 sweets. How many sweets does Zinzi give to Joe?*	**2**
	Zinzi has 4 sweets. Joe has 1 sweet. How many sweets does Joe have less than Zinzi?	**3**
♦	*Zinzi has 7 sweets. Joe has 3 sweets. How many sweets does Joe have less than Zinzi?*	**4**
■	*Zinzi and Joe have 9 sweets together. Zinzi has 1 sweet. How many sweets does Joe have?*	**8**
	Zinzi has 8 sweets. Then she gives some to Joe. Now Zinzi has 6 sweets. How many sweets does Zinzi give to Joe?	**2**

(Wait for all participants to complete last story sum).

Thank you everyone, please put your pencils down and put the counters inside the box. (Let participants do this).

Well done guys! Please stand up and push your chairs in.

See you all tomorrow! Today you each get another sticker for doing so well!

(let participants lead out and give each one a sticker as they leave).

Baseline Probes Script Day Three

Morning everyone! So today you are going to do a few more story sums. Remember to work by yourself and don't look at anyone else's work. You still have the board with red and purple blocks and pictures of children and counters to work out the answers. Today you have a new answer sheet with coloured pictures and numbers (show) *to circle your answers with the pencil.*

I am going to read a story sum to you two times like before. Then you must work out the answer and circle it on the answer sheet. Remember, don't tell me the answer, you just circle it because your answer is your secret! If you make a mistake please put up your hand and I will come and help you. Do any of you have questions? (answer any questions raised)*.*

Okay so let's start!

	Zinzi has 5 sweets. Joe has 3 sweets. How many sweets does Joe have less than Zinzi?	**2**
	Zinzi and Joe have 6 sweets together. Zinzi has 5 sweets. How many sweets does Joe have?	**1**
	Zinzi has 4 sweets. Joe has 1 sweet. How many sweets does Joe have less than Zinzi?	**3**
	Zinzi has 8 sweets. Then she gives some to Joe. Now Zinzi has 6 sweets. How many sweets does Zinzi give to Joe?	**2**
	Zinzi and Joe have 5 sweets together. Zinzi has 2 sweets. How many sweets does Joe have?	**3**
	Zinzi has 7 sweets. Joe has 3 sweets. How many sweets does Joe have less than Zinzi?	**4**
	Zinzi and Joe have 9 sweets together. Zinzi has 3 sweets. How many sweets does Joe have?	**6**
	Zinzi has 10 sweets. Then she gives some to Joe. Now Zinzi has 8 sweets. How many sweets does Zinzi give to Joe?	**8**
	Zinzi has 10 sweets. Joe has 4 sweets. How many sweets does Joe have less than Zinzi?	**6**
	Zinzi and Joe have 8 sweets together. Zinzi has 3 sweets. How many sweets does Joe have?	**5**
	Zinzi has 8 sweets. Joe has 1 sweet. How many sweets does Joe have less than Zinzi?	**7**
	Zinzi has 9 sweets. Then she gives some to Joe. Now Zinzi has 5 sweets. How many sweets does Zinzi give to Joe?	**4**
	Zinzi and Joe have 9 sweets together. Zinzi has 1 sweet. How many sweets does Joe have?	**8**
	Zinzi has 7 sweets. Then she gives some to Joe. Now Zinzi has 2 sweets. How many sweets does Zinzi give to Joe?	**6**
	Zinzi has 3 sweets. Joe has 2 sweets. How many sweets does Joe have less than Zinzi?	**1**
	Zinzi has 5 sweets. Then she gives some to Joe. Now Zinzi has 4 sweets. How many sweets does Zinzi give to Joe?	**1**
	Zinzi and Joe have 10 sweets together. Zinzi has 1 sweet. How many sweets does Joe have?	**9**
	Zinzi has 6 sweets. Then she gives some to Joe. Now Zinzi has 0 sweets. How many sweets does Zinzi give to Joe?	**6**

(Wait for all participants to complete last story sum).

*Thank you everyone, please put your pencils down and put the counters inside the box. (*Let participants do this*).*

Well done guys! Please stand up and push your chairs in.

See you all tomorrow! Today you each get another sticker for doing so well!

*(*let participants lead out and give each one a sticker as they leave*).*

Appendix O
Intervention phase probe scripts

Intervention Probes Script Day One

*Welcome back everyone, I hope you enjoyed your break! Before the break we worked through the story sums using these pictures, counters and boxes (*indicate to facilitator board*). We helped each other work out the answers for the story sums. But this time we are not going to help each other. This time we are going to work out the answers alone and remember your answers are your secret!*

*When we do the story sums I want you to work by yourself and not look at anyone else's work. In front of you is your board with red and purple blocks, your white counters, your pencil and a new answer sheet (*show*).*

*I am going to read a story sum to you and then I will read it again. After that you need to work out the answer for the story sum. When you know the answer you will circle it on the answer sheet, just like you did before. If you make a mistake please put up your hand and I will come and help you. Do any of you have questions? (*answer any questions raised*).*

Now we are going to start. I will read the story sum two times.

	Zinzi has 8 sweets. Then she gives some to Joe. Now Zinzi has 6 sweets. How many sweets does Zinzi give to Joe?	**2**
	Zinzi has 6 sweets. Then she gives some to Joe. Now Zinzi has 0 sweets. How many sweets does Zinzi give to Joe?	**6**
?	*Zinzi has 8 sweets. Joe has 1 sweet. How many sweets does Joe have less than Zinzi?*	**7**
	Zinzi and Joe have 10 sweets together. Zinzi has 1 sweet. How many sweets does Joe have?	**9**
	Zinzi has 5 sweets. Then she gives some to Joe. Now Zinzi has 4 sweets. How many sweets does Zinzi give to Joe?	**1**

✍	*Zinzi and Joe have 5 sweets together. Zinzi has 2 sweets. How many sweets does Joe have?*	**3**
✓	*Zinzi and Joe have 9 sweets together. Zinzi has 3 sweets. How many sweets does Joe have?*	**6**
🚑	*Zinzi has 10 sweets. Joe has 4 sweets. How many sweets does Joe have less than Zinzi?*	**6**
🚌	*Zinzi and Joe have 8 sweets together. Zinzi has 3 sweets. How many sweets does Joe have?*	**5**
✂	*Zinzi has 9 sweets. Then she gives some to Joe. Now Zinzi has 5 sweets. How many sweets does Zinzi give to Joe?*	**4**
♦	*Zinzi has 7 sweets. Joe has 3 sweets. How many sweets does Joe have less than Zinzi?*	**4**
✈	*Zinzi and Joe have 6 sweets together. Zinzi has 5 sweets. How many sweets does Joe have?*	**1**
🐈	*Zinzi has 3 sweets. Joe has 2 sweets. How many sweets does Joe have less than Zinzi?*	**1**
■	*Zinzi and Joe have 9 sweets together. Zinzi has 1 sweet. How many sweets does Joe have?*	**8**
⇨	*Zinzi has 10 sweets. Then she gives some to Joe. Now Zinzi has 8 sweets. How many sweets does Zinzi give to Joe?*	**2**
✐	*Zinzi has 5 sweets. Joe has 3 sweets. How many sweets does Joe have less than Zinzi?*	**2**
✋	*Zinzi has 4 sweets. Joe has 1 sweet. How many sweets does Joe have less than Zinzi?*	**3**
♥	*Zinzi has 7 sweets. Then she gives some to Joe. Now Zinzi has 2 sweets. How many sweets does Zinzi give to Joe?*	**5**

(Wait for all participants to complete last story sum).

Thank you everyone. Please put your pencils down on your table. Now put the ten counters inside the box. (Let participants do this).

You may stand up now and push your chairs in.

*I'll see you all tomorrow again, enjoy the rest of your day! As you go out to class you may each have a sticker for all your hard work! (*let participants lead out and give each one a sticker as they leave*).*

Intervention Probes Script Day Two

Hello everyone! Please sit down again. In front of you are new answer sheets, but you still have your pencil, counters and card with the red and purple blocks to work out the story sums.

Like yesterday, you are all going to work by yourselves now so you may not look at anyone else's work.

I will read each story sum to you two times like yesterday. Then work out the answer and circle it on the answer sheet. Remember, don't tell me the answer, just circle it! If you make a mistake please put up your hand and I will come and help you.

So let's begin…

	Zinzi and Joe have 6 sweets together. Zinzi has 5 sweets. How many sweets does Joe have?	**1**
	Zinzi has 5 sweets. Then she gives some to Joe. Now Zinzi has 4 sweets. How many sweets does Zinzi give to Joe?	**1**
	Zinzi has 7 sweets. Joe has 3 sweets. How many sweets does Joe have less than Zinzi?	**4**
	Zinzi has 3 sweets. Joe has 2 sweets. How many sweets does Joe have less than Zinzi?	**1**
	Zinzi has 8 sweets. Then she gives some to Joe. Now Zinzi has 6 sweets. How many sweets does Zinzi give to Joe?	**2**
	Zinzi and Joe have 5 sweets together. Zinzi has 2 sweets. How many sweets does Joe have?	**3**
	Zinzi has 10 sweets. Joe has 4 sweets. How many sweets does Joe have less than Zinzi?	**6**
	Zinzi has 9 sweets. Then she gives some to Joe. Now Zinzi has 5 sweets. How many sweets does Zinzi give to Joe?	**4**
	Zinzi and Joe have 10 sweets together. Zinzi has 1 sweet. How many sweets does Joe have?	**9**
	Zinzi and Joe have 9 sweets together. Zinzi has 1 sweet. How many sweets does Joe have?	**8**
?	*Zinzi has 8 sweets. Joe has 1 sweet. How many more sweets does Zinzi have than Joe?*	**7**
	Zinzi has 10 sweets. Then she gives some to Joe. Now Zinzi has 8 sweets. How many sweets does Zinzi give to Joe?	**2**
	Zinzi has 7 sweets. Then she gives some to Joe. Now Zinzi has 2 sweets. How many sweets does Zinzi give to Joe?	**5**
✓	*Zinzi and Joe have 9 sweets together. Zinzi has 3 sweets. How many sweets does Joe have?*	**6**
	Zinzi and Joe have 8 sweets together. Zinzi has 3 sweets. How many sweets does Joe have?	**5**
	Zinzi has 4 sweets. Joe has 1 sweet. How many sweets does Joe have less than Zinzi?	**3**
	Zinzi has 6 sweets. Then she gives some to Joe. Now Zinzi has 0 sweets. How many sweets does Zinzi give to Joe?	**6**
	Zinzi has 5 sweets. Joe has 3 sweets. How many more sweets does Zinzi have than Joe?	**2**

(Wait for all participants to complete last story sum).

Thank you everyone, please put your pencils down and put the counters inside the box. *(*Let participants do this*).*

Great work! Please stand up and push your chairs in.

*See you tomorrow! You can each get another sticker for doing so well! (*let participants lead out and give each one a sticker as they leave*).*

Intervention Probes Script Day Three

Hello everyone! I hope you are ready for the next for story sums that you have to do by yourself.

There is a new answer sheet to circle your answers on your table.

I am going to read a story sum to you two times like before. Then work out the answer and circle it on the answer sheet.

Everyone ready? Let's start!

✂	*Zinzi has 9 sweets. Then she gives some to Joe. Now Zinzi has 5 sweets. How many sweets does Zinzi give to Joe?*	**4**
■	*Zinzi and Joe have 9 sweets together. Zinzi has 1 sweet. How many sweets does Joe have?*	**8**
	Zinzi has 6 sweets. Then she gives some to Joe. Now Zinzi has 0 sweets. How many sweets does Zinzi give to Joe?	**0**
	Zinzi and Joe have 8 sweets together. Zinzi has 3 sweets. How many sweets does Joe have?	**5**
?	*Zinzi has 8 sweets. Joe has 1 sweet. How many sweets does Joe have less than Zinzi?*	**7**
⇨	*Zinzi has 10 sweets. Then she gives some to Joe. Now Zinzi has 8 sweets. How many sweets does Zinzi give to Joe?*	**2**
	Zinzi and Joe have 6 sweets together. Zinzi has 5 sweets. How many sweets does Joe have?	**1**
	Zinzi has 3 sweets. Joe has 2 sweets. How many sweets does Joe have less than Zinzi?	**1**
✓	*Zinzi and Joe have 9 sweets together. Zinzi has 3 sweets. How many sweets does Joe have?*	**6**
	Zinzi has 10 sweets. Joe has 4 sweets. How many sweets does Joe have less than?	**6**
	Zinzi has 5 sweets. Then she gives some to Joe. Now Zinzi has 4 sweets. How many sweets does Zinzi give to Joe?	**1**
	Zinzi and Joe have 10 sweets together. Zinzi has 1 sweet. How many sweets does Joe have?	**9**
♦	*Zinzi has 7 sweets. Joe has 3 sweets. How many sweets does Joe have less than Zinzi?*	**4**
	Zinzi has 8 sweets. Then she gives some to Joe. Now Zinzi has 6 sweets. How many sweets does Zinzi give to Joe?	**2**
♥	*Zinzi has 7 sweets. Then she gives some to Joe. Now Zinzi has 2 sweets. How many sweets does Zinzi give to Joe?*	**6**
	Zinzi has 5 sweets. Joe has 3 sweets. How many sweets does Joe have less than Zinzi?	**2**
	Zinzi and Joe have 5 sweets together. Zinzi has 2 sweets. How many sweets does Joe have?	**3**
	Zinzi has 4 sweets. Joe has 1 sweet. How many sweets does Joe have less than Zinzi?	**3**

*(*Wait for all participants to complete last story sum*).*

*Thank you everyone, please put your pencils down and put the counters inside the box. (*Let participants do this*).*

Well done guys! Please stand up and push your chairs in.

See you all tomorrow! Today you each get another sticker for doing so well!

*(*let participants lead out and give each one a sticker as they leave*).*

Intervention Probes Script Day Four

Welcome back everyone! Please sit down so we can do our story sums. Remember these are the ones that you have to do by yourself.

There is a new answer sheet to circle your answers on your table.

I am going to read a story sum to you two times like before. Then work out the answer and circle it on the answer sheet.

Everyone ready? Let's start!

⇨	*Zinzi has 10 sweets. Then she gives some to Joe. Now Zinzi has 8 sweets. How many sweets does Zinzi give to Joe?*	**2**
?	*Zinzi has 8 sweets. Joe has 1 sweet. How many sweets does Joe have less than Zinzi?*	**7**
♥	*Zinzi has 7 sweets. Then she gives some to Joe. Now Zinzi has 2 sweets. How many sweets does Zinzi give to Joe?*	**5**
	Zinzi and Joe have 10 sweets together. Zinzi has 1 sweet. How many sweets does Joe have?	**9**
	Zinzi has 10 sweets. Joe has 4 sweets. How many sweets does Joe have less than Zinzi?	**6**
	Zinzi has 3 sweets. Joe has 2 sweets. How many sweets does Joe have less than Zinzi?	**1**
	Zinzi has 6 sweets. Then she gives some to Joe. Now Zinzi has 0 sweets. How many sweets does Zinzi give to Joe?	**6**
	Zinzi and Joe have 6 sweets together. Zinzi has 5 sweets. How many sweets does Joe have?	**1**
	Zinzi has 5 sweets. Then she gives some to Joe. Now Zinzi has 4 sweets. How many sweets does Zinzi give to Joe?	**1**
♦	*Zinzi has 7 sweets. Joe has 3 sweets. How many sweets does Joe have less than Zinzi?*	**4**
	Zinzi has 5 sweets. Joe has 3 sweets. How many sweets does Joe have less than Zinzi?	**2**
	Zinzi and Joe have 5 sweets together. Zinzi has 2 sweets. How many sweets does Joe have?	**3**
✂	*Zinzi has 9 sweets. Then she gives some to Joe. Now Zinzi has 5 sweets. How many sweets does Zinzi give to Joe?*	**4**
✓	*Zinzi and Joe have 9 sweets together. Zinzi has 3 sweets. How many sweets does Joe have?*	**6**
	Zinzi has 4 sweets. Joe has 1 sweet. How many sweets does Joe have less than Zinzi?	**3**
■	*Zinzi and Joe have 9 sweets together. Zinzi has 1 sweet. How many sweets does Joe have?*	**8**
	Zinzi has 8 sweets. Then she gives some to Joe. Now Zinzi has 6 sweets. How many sweets does Zinzi give to Joe?	**2**
	Zinzi and Joe have 8 sweets together. Zinzi has 3 sweets. How many sweets does Joe have?	**5**

(Wait for all participants to complete last story sum).

Thank you! Please put your pencils down and put the counters inside the box. (Let participants do this*).*

Good work! Please stand up and push your chairs in.

*Enjoy the rest of your day! You may each have a sticker today! (*let participants lead out and give each one a sticker as they leave*).*

Intervention Probes Script Day Five

Come in everyone! Today is the last day of doing story sums before the weekend! I hope your thinking caps are on because remember these are the ones you work out by yourself.

There is a new answer sheet to circle your answers on your table.

I am going to read a story sum to you two times. Then work out the answer and circle it on the answer sheet.

Everyone ready? Let's start!

	Zinzi and Joe have 5 sweets together. Zinzi has 2 sweets. How many sweets does Joe have?	**3**
	Zinzi has 10 sweets. Then she gives some to Joe. Now Zinzi has 8 sweets. How many sweets does Zinzi give to Joe?	**2**
	Zinzi has 7 sweets. Joe has 3 sweets. How many sweets does Joe have less than Zinzi ?	**4**
	Zinzi and Joe have 8 sweets together. Zinzi has 3 sweets. How many sweets does Joe have?	**5**
	Zinzi has 7 sweets. Then she gives some to Joe. Now Zinzi has 2 sweets. How many sweets does Zinzi give to Joe?	**5**
	Zinzi and Joe have 10 sweets together. Zinzi has 1 sweet. How many sweets does Joe have?	**9**
	Zinzi has 9 sweets. Then she gives some to Joe. Now Zinzi has 5 sweets. How many sweets does Zinzi give to Joe?	**4**
	Zinzi has 5 sweets. Joe has 3 sweets. How many sweets does Joe have less than Zinzi?	**2**
✓	*Zinzi and Joe have 9 sweets together. Zinzi has 3 sweets. How many sweets does Joe have?*	**6**
	Zinzi has 4 sweets. Joe has 1 sweet. How many sweets does Joe have less than Zinzi?	**3**
	Zinzi has 5 sweets. Then she gives some to Joe. Now Zinzi has 4 sweets. How many sweets does Zinzi give to Joe?	**1**
	Zinzi has 3 sweets. Joe has 2 sweets. How many sweets does Joe have less than Zinzi?	**1**
	Zinzi has 6 sweets. Then she gives some to Joe. Now Zinzi has 6 sweets. How many sweets does Zinzi give to Joe?	**6**
?	*Zinzi has 8 sweets. Joe has 1 sweet. How many sweets does Joe have less than Zinzi?*	**7**
	Zinzi and Joe have 6 sweets together. Zinzi has 5 sweets. How many sweets does Joe have?	**1**
	Zinzi has 8 sweets. Then she gives some to Joe. Now Zinzi has 6 sweets. How many sweets does Zinzi give to Joe?	**2**
	Zinzi has 10 sweets. Joe has 4 sweets. How many sweets does Joe have less than Zinzi?	**6**
■	*Zinzi and Joe have 9 sweets together. Zinzi has 1 sweet. How many sweets does Joe have?*	**8**

(Wait for all participants to complete last story sum).

*Well done everybody! You may put your pencils down and the counters inside the box. (*Let participants do this*).*

Good work! Please stand up and push your chairs in.

*I hope you all have a wonderful weekend! You each get a sticker for today's hard work! (*let participants lead out and give each one a sticker as they leave*).*

Appendix P
Maintenance phase probe scripts

Maintenance Probe Script Day One

*Hello everybody! It's been such a long time since I saw you all, but it's really great to be with you again. Last time I came you all helped me to work out some story sums do you remember? (*let participants respond*) today I came back to do other story sums with you. We are going to do them like last time. So let me remind you…*

I will read out a story sum and you have to work out the answer by yourself. When you know the answer you circle it on your answer sheet. Remember these cards with the children's pictures on and the counters in this box? Well you can use them again if you like.

I am going to read each story sum to you two times. After that you will get some time to work out the answers. Then circle it on the answer sheet. The story sums are still about the two children; Zinzi and Joe. Let's first do the story sum for the black book. Please work out the answer for this story sum…

*Zinzi has three sweets, then she gives some to Joe. Now Zinzi has three sweets. How many sweets does Zinzi give to Joe? Listen again…(*repeat*).*

*Now, please find the answer next to the black book and circle it (*check that participants circle a number*).*

(Assist participants with circling a number next to the example block symbolized by the black book where necessary). *Good!*

*Now we are going to do the other story sums in the same way. Remember, your answer is your secret so don't tell anyone the answer, just circle it. If you make a mistake please put up your hand and I will come and help you. Do any of you have questions? (*answer any questions raised*).*

*Okay let's do these story sums… (*conduct each word problem as described for the example item*).*

✓	*Zinzi and Joe have 9 sweets together. Zinzi has 3 sweets. How many sweets does Joe have?*	**6**
♥	*Zinzi has 7 sweets. Then she gives some to Joe. Now Zinzi has 2 sweets. How many sweets does Zinzi give to Joe?*	**5**
✎	*Zinzi has 5 sweets. Joe has 3 sweets. How many sweets does Joe have less than Zinzi?*	**2**
	Zinzi has 8 sweets. Then she gives some to Joe. Now Zinzi has 6 sweets. How many sweets does Zinzi give to Joe?	**2**
	Zinzi and Joe have 8 sweets together. Zinzi has 3 sweets. How many sweets does Joe have?	**5**
⇨	*Zinzi has 10 sweets. Then she gives some to Joe. Now Zinzi has 8 sweets. How many sweets does Zinzi give to Joe?*	**2**
?	*Zinzi has 8 sweets. Joe has 1 sweet. How many sweets does Joe have less than Zinzi?*	**7**
	Zinzi and Joe have 5 sweets together. Zinzi has 2 sweets. How many sweets does Joe have?	**3**
	Zinzi has 3 sweets. Joe has 2 sweets. How many sweets does Joe have less than Zinzi?	**1**
	Zinzi and Joe have 10 sweets together. Zinzi has 1 sweet. How many sweets does Joe have?	**9**
♦	*Zinzi has 7 sweets. Joe has 3 sweets. How many sweets does Joe have less than Zinzi?*	**4**
■	*Zinzi and Joe have 9 sweets together. Zinzi has 1 sweet. How many sweets does Joe have?*	**8**
	Zinzi has 6 sweets. Then she gives some to Joe. Now Zinzi has 0 sweets. How many sweets does Zinzi give to Joe?	**6**
	Zinzi has 10 sweets. Joe has 4 sweets. How many sweets does Joe have less than Zinzi?	**6**
✂	*Zinzi has 9 sweets. Then she gives some to Joe. Now Zinzi has 5 sweets. How many sweets does Zinzi give to Joe?*	**4**
	Zinzi and Joe have 6 sweets together. Zinzi has 5 sweets. How many sweets does Joe have?	**1**
	Zinzi has 5 sweets. Then she gives some to Joe. Now Zinzi has 4 sweets. How many sweets does Zinzi give to Joe?	**1**
	Zinzi has 4 sweets. Joe has 1 sweet. How many sweets does Joe have less than Zinzi?	**3**

(Wait for all participants to complete last story sum).

*I see you are all done so please put your pencils down. Next put the ten counters back inside the little box. (*Let participants do this*). Thank you all, please stand up now and push your chairs in. Great job everyone!*

Maintenance Probe Script Day Two

Hello everyone! Nice to see you all again today. You are going to work out some story sum answers again, just like we did yesterday.

*Remember to work by yourself and don't look at anyone else's work. You have your answer sheet, the board like this one (*point to facilitator board*), counters to work out the answers and your pencils.*

I am going to read each story sum to you two times like yesterday. Then you must please work out the answer and circle it on the answer sheet.

*Remember, you don't tell me the answer, you just circle it because your answer is your secret! Do any of you have questions? (*answer any questions raised*). So let's start...*

	Zinzi has 3 sweets. Joe has 2 sweets. How many sweets does Joe have less than Zinzi?	**1**
	Zinzi and Joe have 5 sweets together. Zinzi has 2 sweets. How many sweets does Joe have?	**3**
	Zinzi has 9 sweets. Then she gives some to Joe. Now Zinzi has 5 sweets. How many sweets does Zinzi give to Joe?	**4**
	Zinzi has 10 sweets. Joe has 4 sweets. How many sweets does Joe have less than Zinzi?	**6**
	Zinzi and Joe have 10 sweets together. Zinzi has 1 sweet. How many sweets does Joe have?	**9**
	Zinzi has 5 sweets. Joe has 3 sweets. How many sweets does Joe have less than Zinzi?	**2**
	Zinzi and Joe have 6 sweets together. Zinzi has 5 sweets. How many sweets does Joe have?	**1**
	Zinzi has 7 sweets. Then she gives some to Joe. Now Zinzi has 2 sweets. How many sweets does Zinzi give to Joe?	**5**
	Zinzi and Joe have 8 sweets together. Zinzi has 3 sweets. How many sweets does Joe have?	**5**
	Zinzi has 6 sweets. Then she gives some to Joe. Now Zinzi has 0 sweets. How many sweets does Zinzi give to Joe?	**6**
	Zinzi has 8 sweets. Joe has 1 sweet. How many sweets does Joe have less than Zinzi?	**7**
	Zinzi and Joe have 9 sweets together. Zinzi has 3 sweets. How many sweets does Joe have?	**6**
	Zinzi has 5 sweets. Then she gives some to Joe. Now Zinzi has 4 sweets. How many sweets does Zinzi give to Joe?	**1**
	Zinzi has 10 sweets. Then she gives some to Joe. Now Zinzi has 8 sweets. How many sweets does Zinzi give to Joe?	**2**
	Zinzi has 4 sweets. Joe has 1 sweet. How many sweets does Joe have less than Zinzi?	**3**
	Zinzi has 7 sweets. Joe has 3 sweets. How many sweets does Joe have less than Zinzi?	**4**
	Zinzi and Joe have 9 sweets together. Zinzi has 1 sweet. How many sweets does Joe have?	**8**
	Zinzi has 8 sweets. Then she gives some to Joe. Now Zinzi has 6 sweets. How many sweets does Zinzi give to Joe?	**2**

(Wait for all participants to complete last story sum).

Thank you everyone, please put your pencils down and put the counters inside the bottle. *(*Let participants do this*).*

Well done guys! Please stand up and push your chairs in.

See you all tomorrow! Today you each get another sticker for doing so well! *(*let participants lead out and give each one a sticker as they leave*).*

Maintenance Probes Script Day Three

Morning everyone! So today you are going to do the last story sums.

*Remember to work by yourself and don't look at anyone else's work. You have a new answer sheet, a board like this one (*point to facilitator board*), counters to work out the answers and your pencil.*

I am going to read a story sum to you two times like before. Then you must work out the answer and circle it on the answer sheet.

Remember, you don't tell me the answer, you just circle it because your answer is your secret!

Okay so let's start!

	Zinzi has 5 sweets. Joe has 3 sweets. How many sweets does Joe have less than Zinzi?	**2**
	Zinzi and Joe have 6 sweets together. Zinzi has 5 sweets. How many sweets does Joe have?	**1**
	Zinzi has 4 sweets. Joe has 1 sweet. How many sweets does Joe have less than Zinzi?	**3**
	Zinzi has 8 sweets. Then she gives some to Joe. Now Zinzi has 6 sweets. How many sweets does Zinzi give to Joe?	**2**
	Zinzi and Joe have 5 sweets together. Zinzi has 2 sweets. How many sweets does Joe have?	**3**
	Zinzi has 7 sweets. Joe has 3 sweets. How many sweets does Joe have less than Zinzi?	**4**
	Zinzi and Joe have 9 sweets together. Zinzi has 3 sweets. How many sweets does Joe have?	**6**
	Zinzi has 10 sweets. Then she gives some to Joe. Now Zinzi has 8 sweets. How many sweets does Zinzi give to Joe?	**8**
	Zinzi has 10 sweets. Joe has 4 sweets. How many sweets does Joe have less than Zinzi?	**6**
	Zinzi and Joe have 8 sweets together. Zinzi has 3 sweets. How many sweets does Joe have?	**5**
	Zinzi has 8 sweets. Joe has 1 sweet. How many sweets does Joe have less than Zinzi?	**7**
	Zinzi has 9 sweets. Then she gives some to Joe. Now Zinzi has 5 sweets. How many sweets does Zinzi give to Joe?	**4**
	Zinzi and Joe have 9 sweets together. Zinzi has 1 sweet. How many sweets does Joe have?	**8**
	Zinzi has 7 sweets. Then she gives some to Joe. Now Zinzi has 2 sweets. How many sweets does Zinzi give to Joe?	**5**
	Zinzi has 3 sweets. Joe has 2 sweets. How many sweets does Joe have less than Zinzi?	**1**
	Zinzi has 5 sweets. Then she gives some to Joe. Now Zinzi has 4 sweets. How many sweets does Zinzi give to Joe?	**1**
	Zinzi and Joe have 10 sweets together. Zinzi has 1 sweet. How many sweets does Joe have?	**9**
	Zinzi has 6 sweets. Then she gives some to Joe. Now Zinzi has 0 sweets. How many sweets does Zinzi give to Joe?	**6**

(Wait for all participants to complete last story sum).

*Thank you everyone, please put your pencils down and put the counters inside the bottle. (*Let participants do this*).*

*Thank you so much for helping me with this work, I hope you had fun doing the story sums. I had lots of fun working with you all and I'm going to miss you! Please remember your sticker as you go! (*let participants lead out and give each one a sticker as they leave*).*

Baseline Session:_ **Appendix Q Baseline probe answer sheets** Participant Nr: ______

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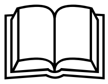	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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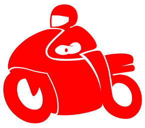	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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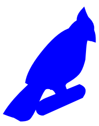
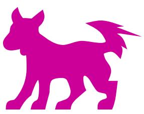
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
	0	1	2	3	4	5	6	7	8	9	10		S1 S2

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Baseline Session:_ **Appendix Q Baseline probe answer sheets** Participant Nr: ______

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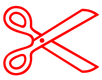
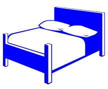
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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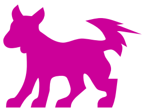
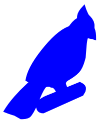
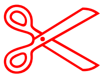
Baseline Session:_ **Appendix Q Baseline probe answer sheets** Participant Nr: ______

	0	1	2	3	4	5	6	7	8	9	10		S1 S2
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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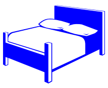	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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Baseline Session:_ **Appendix Q Baseline probe answer sheets** Participant Nr: ______

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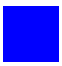	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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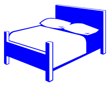	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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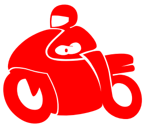
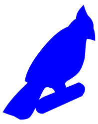
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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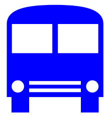
Baseline Session:_ **Appendix Q Baseline probe answer sheets** Participant Nr: ______

	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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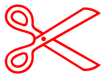	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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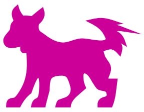	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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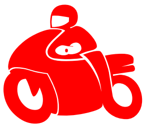
	B1	B2	B3
S1			
S2			
TOTAL			

	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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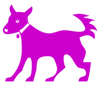	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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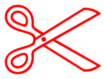
	Behaviour 1	Behaviour 2	Behaviour 3
S1			
S2			
TOTAL			

	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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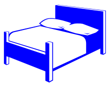
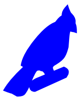
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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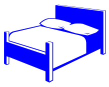
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
	0	1	2	3	4	5	6	7	8	9	10		S1 S2

	Behaviour 1	Behaviour 2	Behaviour 3
S1			
S2			
TOTAL			

Intervention Session: ____ **Appendix R l** **e answer sheets** Participant Nr: _____

	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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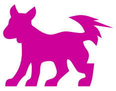
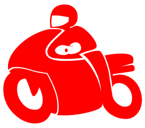
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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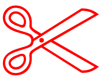	0	1	2	3	4	5	6	7	8	9	10		S1 S2
	0	1	2	3	4	5	6	7	8	9	10		S1 S2

	Behaviour 1	Behaviour 2	Behaviour 3
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?	0	1	2	3	4	5	6	7	8	9	10		S1 S2
⇨	0	1	2	3	4	5	6	7	8	9	10		S1 S2
♥	0	1	2	3	4	5	6	7	8	9	10		S1 S2
✓	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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	Behaviour 1	Behaviour 2	Behaviour 3
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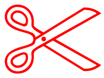	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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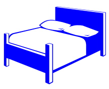
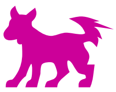
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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	Behaviour 1	Behaviour 2	Behaviour 3
S1			
S2			
TOTAL			

	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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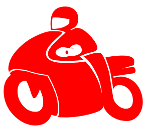	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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	0	1	2	3	4	5	6	7	8	9	10		S1 S2

	Behaviour 1	Behaviour 2	Behaviour 3
S1			
S2			
TOTAL			

Intervention Session: ____ **Appendix R l****e answer sheets** Participant Nr: _____

	0	/	2	3	4	5	6	7	8	9	/0		S1 S2
	0	/	2	3	4	5	6	7	8	9	/0		S1 S2
	0	/	2	3	4	5	6	7	8	9	/0		S1 S2
	0	/	2	3	4	5	6	7	8	9	/0		S1 S2
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	0	/	2	3	4	5	6	7	8	9	/0		S1 S2
	0	/	2	3	4	5	6	7	8	9	/0		S1 S2
	0	/	2	3	4	5	6	7	8	9	/0		S1 S2
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	Behaviour 1	Behaviour 2	Behaviour 3
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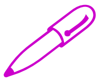
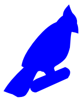
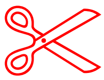
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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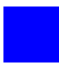
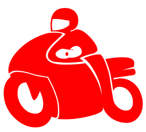
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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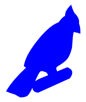
	Behaviour 1	Behaviour 2	Behaviour 3
S1			
S2			
TOTAL			

Intervention Session: ____ **Appendix R 1** **e answer sheets** Participant Nr: _____

	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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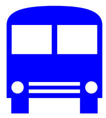	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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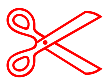	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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	Behaviour 1	Behaviour 2	Behaviour 3
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TOTAL			

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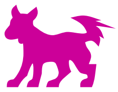	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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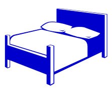	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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	Behaviour 1	Behaviour 2	Behaviour 3
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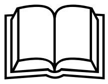	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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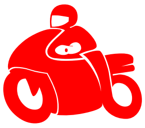	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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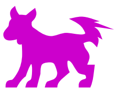	0	1	2	3	4	5	6	7	8	9	10		S1 S2

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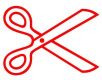
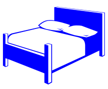
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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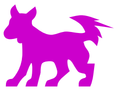
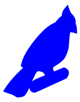
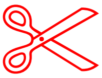
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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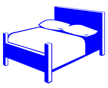	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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	0	1	2	3	4	5	6	7	8	9	10		S1 S2

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✓	0	1	2	3	4	5	6	7	8	9	10		S1 S2
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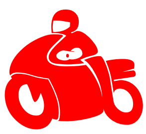
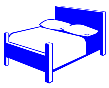
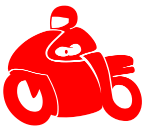
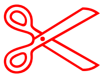
⇨	0	1	2	3	4	5	6	7	8	9	10		S1 S2
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
◆	0	1	2	3	4	5	6	7	8	9	10		S1 S2
■	0	1	2	3	4	5	6	7	8	9	10		S1 S2
	0	1	2	3	4	5	6	7	8	9	10		S1 S2

	B1	B2	B3
S1			
S2			
TOTAL			

	0	1	2	3	4	5	6	7	8	9	10		**S1** **S2**
	0	1	2	3	4	5	6	7	8	9	10		**S1** **S2**
	0	1	2	3	4	5	6	7	8	9	10		**S1** **S2**
	0	1	2	3	4	5	6	7	8	9	10		**S1** **S2**
	0	1	2	3	4	5	6	7	8	9	10		**S1** **S2**
	0	1	2	3	4	5	6	7	8	9	10		**S1** **S2**
	0	1	2	3	4	5	6	7	8	9	10		**S1** **S2**
	0	1	2	3	4	5	6	7	8	9	10		**S1** **S2**
	0	1	2	3	4	5	6	7	8	9	10		**S1** **S2**

	B1	B2	B3
S1			
S2			
TOTAL			

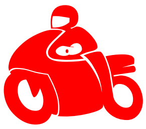
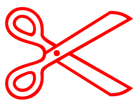
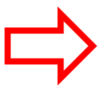
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
	0	1	2	3	4	5	6	7	8	9	10		S1 S2
	0	1	2	3	4	5	6	7	8	9	10		S1 S2

	B1	B2	B3
S1			
S2			
TOTAL			

Date: ______________________________ Participant nr: ______

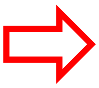
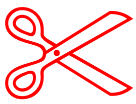
Appendix T
Intervention answer sheets

Change Teaching Items 1

	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10

Date: ______________________________ Participant nr: ______

Change Teaching Items 2

	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10

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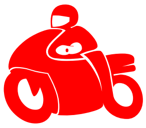
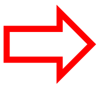
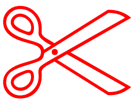
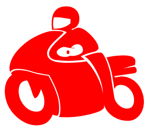
Date: ______________________________ Participant nr: ______

Change Teaching Items 3

	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10

Date: ______________________________ Participant nr: ______

Change Teaching Items 4

	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
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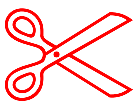	0	1	2	3	4	5	6	7	8	9	10

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Date: ______________________________ Participant nr: ______

Change Teaching Items 5

	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10

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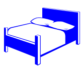
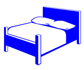
Date: ______________________________ Participant nr: ______

Combine Teaching Items 1

■	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
✓	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10

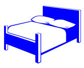
Date: ______________________________ Participant nr: ______

Combine Teaching Items 2

✓	0	1	2	3	4	5	6	7	8	9	10
■	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10

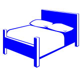
Date: ______________________________ Participant nr: ______

Combine Teaching Items 3

	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
✓	0	1	2	3	4	5	6	7	8	9	10
■	0	1	2	3	4	5	6	7	8	9	10

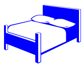
Date: ______________________________ Participant nr: ______

Combine Teaching Items 4

	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10

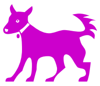
Date: ______________________________ Participant nr: ______

Combine Teaching Items 5

	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
✓	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
■	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10

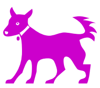
Date: ______________________________ Participant nr: ______

Compare Teaching Items 1

	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
?	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10

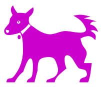
Date: ______________________________ Participant nr: _______

Compare Teaching Items 2

	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10

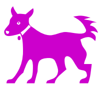
Date: ______________________________ Participant nr: ______

Compare Teaching Items 3

?	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
♦	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10

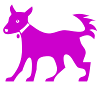
Date: ______________________________ Participant nr: ______

Compare Teaching Items 4

	0	1	2	3	4	5	6	7	8	9	10
◆	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
?	0	1	2	3	4	5	6	7	8	9	10

Date: ______________________________ Participant nr: ______

Compare Teaching Items 5

	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
?	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10
	0	1	2	3	4	5	6	7	8	9	10

Appendix U

Pilot Study 1 Participants

	FIRST PILOT STUDY							
Participant / **Criteria**	**Participant A**	**Participant B**	**Participant C**	**Participant D**	**Participant E**	**Participant F**	**Participant G**	**Participant H**
Pseudonym	Participant A	Participant B	Participant C	Participant D	Participant E	Participant F	Participant G	Participant H
Gender	Female	Male	Male	Male	Male	Male	Male	Female
Chronological Age	9.09	10.04	9.07	8.01	8.07	11.00	8.08	8.10
First Language	English	English	Sesotho	isiZulu	Sesotho	English	Tswana	English
Primary Diagnosis	Speech impediment	Heart condition	ADHD	ADHD	Generalized Developmental Delay	ADHD	Learning difficulties caused by trauma	Epilepsy
Attendance duration at current school	2 years	1.5 years	1 year	1 year	6 months	2.5 years	2 years	6 months
Physical Impairments	None	None	None	None	None	None	None	None
Sensory Impairments	Speech impediment	None	None	None	None	Articulation difficulties	None	None
Gross Motor Skills	No difficulties	No difficulties	No difficulties	No difficulties	No difficulties	No difficulties	No difficulties	No difficulties
Fine Motor Skills	Battles to hold small objects in left hand.	No difficulties	No difficulties	No difficulties	No difficulties	No difficulties	No difficulties	No difficulties
Adaptive Behaviours (Daily routine)	Independent in terms of mobility and self-care but needs help with dressing due to fine motor difficulty.	Independent in terms of mobility and self-care	Independent in terms of mobility and self-care	Independent in terms of mobility and self-care	Independent in terms of mobility and self-care	Independent in terms of mobility and self-care	Independent in terms of mobility and self-care	Independent in terms of mobility and self-care
Intelligence Quotient Raven[a] / KBit-2[b]	65	60	80	65	70	<60	65	60
Receptive language age equivalent score (Peabody Picture Vocabulary Test-4)	7.06	6.05	6.07	5.00	4.10	6.10	6.08	5.09
Expressive language age equivalent score (OWLS-II)	4.01	4.08	6.00	5.02	5.10	5.08	6.00	4.08
Numerical operations age equivalent score (WIAT-II)	5.00	6.04	6.08	5.04	6.08	5.08	7.00	5.04
Mathematical reasoning age equivalent score (WIAT-II)	4.04	6.04	6.00	5.04	5.08	5.04	6.04	5.04
Informal Counting Test	Not tested	Not tested	Not tested	Not tested	Not tested	Not tested	Not tested	Not tested
PCS Identification Test	49% after 1st trial	47% after 1st trial	41% after 1st trial	43% after 1st trial	43% after 1st trial	100% after 1st trial	98% after 1st trial	62% after 1st trial
History of AAC exposure	Exposure in the form of labels	Exposure in the form of labels	Exposure in the form of labels	Exposure in the form of labels	Exposure in the form of labels	Exposure in the form of labels	Exposure in the form of labels	Exposure in the form of labels

Appendix V

Pilot Study 2 participants

	SECOND PILOT STUDY	
Participant / **Criteria**	**Participant I**	**Participant J**
Pseudonym	Participant I	Participant J
Gender	Female	Male
Chronological Age	9.06	9.07
First Language	English	English
Primary Diagnosis	Generalized Developmental Delay	Generalized Developmental Delay
Attendance duration at current school	3 years	3.5 years
Physical Impairments	None	None
Sensory Impairments	None	None
Gross Motor Skills	No difficulties	No difficulties
Fine Motor Skills	No difficulties	No difficulties
Adaptive Behaviours (Daily routine)	Independent in terms of mobility and self-care	Independent in terms of mobility and self-care
Intelligence Quotient Raven[a] / KBit-2[b]	55	53
Receptive language age equivalent score (Peabody Picture Vocabulary Test-4)	5.09	5.01
Numerical operations age equivalent score (WIAT-II)	5.08	5.08
Mathematical reasoning age equivalent score (WIAT-II)	5.04	5.08
Informal Counting Test	100%	100%
PCS symbols Identification Test	100% after 4th trial	97% after 4th trial
History of AAC exposure	Exposure in lessons in the form of labels	Exposure in lessons in the form of labels

Appendix W

Procedural integrity checklist: probe sessions

PROCEDURAL INTEGRITY CHECKLIST: PROBE SESSIONS

Procedure	Done	Omitted
Venue preparation		
- Tables and chairs are available for all participants		
- Facilitator board is placed centrally in full view of all participants		
- Picture Communication Symbols are placed in a 36 matrix		
- Lighting is adequate		
Introduce mathematical word-problem solving		
- Ensure all participants are seated comfortably		
- Explain that participants will solve story sums independently		
- Present materials (A4 facilitator board replica, manipulatives, pencil and probe answer sheet)		
Present mathematical word-problems		
- Sit / stand in a position in full view of all participants		
- Speak slowly and clearly		
- Present word-problems in accordance with probe test script format		
- Repeat word-problem twice		
- Give non-contingent reinforcement		
- Fluid transition to new word-problem		
Closing		
- End probe test with a closing statement		
- Facilitate packing away of A4 facilitator board replicas, manipulatives, pencils and probe answer sheets		
- Greet participants and prepare them for session on the following day		

Completed by: ______________________________

Session date and (number): ______________ (   )

Appendix X

Procedural integrity checklist: intervention sessions

PROCEDURAL INTEGRITY CHECKLIST: INTERVENTION SESSIONS

Procedure	Done	Omitted
Venue preparation		
- Tables and chairs are available for all participants		
- Facilitator board is placed centrally in full view of all participants		
- Sit to the side of the facilitator board so that participant view is not obstructed		
- Picture Communication Symbols are placed in a 36 matrix		
- Lighting is adequate		
Greeting		
- Welcome participants		
- Ensure all participants are seated comfortably and can see the facilitator board		
Introduce mathematical word-problem solving		
- Explain that we will be solving story sums today		
- Present materials (Facilitator board, manipulatives, answer sheets, pencils)		
Present mathematical word-problems		
- Present word-problems in accordance with script format		
- Demonstrate word-problem solutions using manipulatives and calculation mats on facilitator board		
- Revise word-problem if participants do not understand the solution		
- Provide opportunities for participants to volunteer answers		
- Encourage all participants to volunteer participants during session		
- Give non-contingent reinforcement		
- Fluid transition to new word-problem		
Application Aided Language Stimulation Principles		
- Speak slowly and clearly		
- Demonstrate familiarity with the symbol locations on the facilitator board		
- Point to Picture Communication Symbol as the word is articulated		
- Use a large percentage of the available vocabulary on the facilitator board		
- Use a ratio of 80: 20 of statements:questions /commands		
- Alternate gaze between participants and facilitator board		
- Allow time for participants to process incoming information		
Closing		
- Prepare participants for probe test to follow break		

Completed by: ____

Session date and (number): _____________________________ (   )

Appendix Y
Probe script checklist

Checklist Legend

✓ : Tick statements if they are used on the script.

~~E.g.~~ : Strike words through that are scripted but not used.

↑ : To indicate a word used that is not scripted.

Question	Word problems	=	Control ✓	~~E.g~~	↑
	Zinzi has 3 sweets. Joe has 2 sweets. How many sweets does Joe have less than Zinzi?	1			
	Zinzi has 3 sweets. Joe has 2 sweets. How many sweets does Joe have less than Zinzi?				
	Zinzi and Joe have 5 sweets together. Zinzi has 2 sweets. How many sweets does Joe have?	3			
	Zinzi and Joe have 5 sweets together. Zinzi has 2 sweets. How many sweets does Joe have?				
	Zinzi has 9 sweets. Then she gives some to Joe. Now Zinzi has 5 sweets. How many sweets does Zinzi give to Joe?	4			
	Zinzi has 9 sweets. Then she gives some to Joe. Now Zinzi has 5 sweets. How many sweets does Zinzi give to Joe?				
	Zinzi has 10 sweets. Joe has 4 sweets. How many sweets does Joe have less than Zinzi?	6			
	Zinzi has 10 sweets. Joe has 4 sweets. How many sweets does Joe have less than Zinzi?				
	Zinzi and Joe have 10 sweets together. Zinzi has 1 sweet. How many sweets does Joe have?	9			
	Zinzi and Joe have 10 sweets together. Zinzi has 1 sweet. How many sweets does Joe have?				
	Zinzi has 5 sweets. Joe has 3 sweets. How many sweets does Joe have less than Zinzi?	2			
	Zinzi has 5 sweets. Joe has 3 sweets. How many sweets does Joe have less than Zinzi?				
	Zinzi and Joe have 6 sweets together. Zinzi has 5 sweets. How many sweets does Joe have?	1			
	Zinzi and Joe have 6 sweets together. Zinzi has 5 sweets. How many sweets does Joe have?				
	Zinzi has 7 sweets. Then she gives some to Joe. Now Zinzi has 2 sweets. How many sweets does Zinzi give to Joe?	5			
	Zinzi has 7 sweets. Then she gives some to Joe. Now Zinzi has 2 sweets. How many sweets does Zinzi give to Joe?				
	Zinzi and Joe have 8 sweets together. Zinzi has 3 sweets. How many sweets does Joe have?	5			
	Zinzi and Joe have 8 sweets together. Zinzi has 3 sweets. How many sweets does Joe have?				

	Zinzi has 6 sweets. Then she gives some to Joe. Now Zinzi has 0 sweets. How many sweets does Zinzi give to Joe?	6			
	Zinzi has 6 sweets. Then she gives some to Joe. Now Zinzi has 0 sweets. How many sweets does Zinzi give to Joe?				
?	Zinzi has 8 sweets. Joe has 1 sweet. How many sweets does Joe have less than Zinzi?	7			
	Zinzi has 8 sweets. Joe has 1 sweet. How many sweets does Joe have less than Zinzi?				
✓	Zinzi and Joe have 9 sweets together. Zinzi has 3 sweets. How many sweets does Joe have?	6			
	Zinzi and Joe have 9 sweets together. Zinzi has 3 sweets. How many sweets does Joe have?				
	Zinzi has 5 sweets. Then she gives some to Joe. Now Zinzi has 4 sweets. How many sweets does Zinzi give to Joe?	1			
	Zinzi has 5 sweets. Then she gives some to Joe. Now Zinzi has 4 sweets. How many sweets does Zinzi give to Joe?				
⇨	Zinzi has 10 sweets. Then she gives some to Joe. Now Zinzi has 8 sweets. How many sweets does Zinzi give to Joe?	2			
	Zinzi has 10 sweets. Then she gives some to Joe. Now Zinzi has 8 sweets. How many sweets does Zinzi give to Joe?				
	Zinzi has 4 sweets. Joe has 1 sweet. How many sweets does Joe have less than Zinzi?	3			
	Zinzi has 4 sweets. Joe has 1 sweet. How many sweets does Joe have less than Zinzi?				
♦	Zinzi has 7 sweets. Joe has 3 sweets. How many sweets does Joe have less than Zinzi?	4			
	Zinzi has 7 sweets. Joe has 3 sweets. How many sweets does Joe have less than Zinzi?				
■	Zinzi and Joe have 9 sweets altogether. Zinzi has 1 sweet. How many sweets does Joe have?	8			
	Zinzi and Joe have 9 sweets altogether. Zinzi has 1 sweet. How many sweets does Joe have?				
	Zinzi has 8 sweets. Then she gives some to Joe. Now Zinzi has 6 sweets. How many sweets does Zinzi give to Joe?	2			
	Zinzi has 8 sweets. Then she gives some to Joe. Now Zinzi has 6 sweets. How many sweets does Zinzi give to Joe?				

✓ Total number statements used accurately (from a possible 36)	
~~E.g~~ Total number words scripted but omitted	
↑ Total number of words used but not scripted	
Total Accuracy Score (✓ - ~~E.g~~ - ↑)	

Appendix Z
MAiLgS programme script checklist: Change type

Checklist Legend

☑ : Tick statements if they are used on the script.

○ : Circle words that are indicated as AiLgS words (capitalized) but are not pointed to.

~~E.g.~~ : Strike words through AiLgS words (capitalized) that are not used.

♥: *Zinzi has 7 sweets. Then she gives some to Joe. Now Zinzi has 2 sweets. How many sweets does Zinzi give to Joe?*

☐ ZINZI HAS 7 SWEETS.

☐ Then, she GIVES SOME to JOE.

☐ Now ZINZI HAS 2 SWEETS.

☐ HOW MANY SWEETS does ZINZI GIVE to JOE?

☐ To work out this ANSWER, we must GIVE ZINZI her 7 SWEETS.

☐ We PUT them here on her red mat.

☐ Let's COUNT ZINZI'S SWEETS…

☐ There, now ZINZI HAS her 7 SWEETS.

☐ But LOOK, JOE HAS no SWEETS yet.

☐ He HAS NOTHING on his purple mat.

☐ So ZINZI is kind, she will SHARE with JOE.

☐ ZINZI will GIVE SOME SWEETS to JOE.

☐ But we DON'T KNOW HOW MANY SWEETS ZINZI GIVES to JOE, because she only says that she will GIVE him SOME.

☐ ZINZI TAKES SOME SWEETS and PUTS them on JOE'S mat, without telling us HOW MANY she PUTS there!

☐ We can FIND HOW MANY ZINZI GIVES to JOE.

☐ To do that we must THINK of HOW MANY ZINZI HAS AFTER she GIVES SOME SWEETS to JOE.

☐ Remember, ZINZI HAS 2 SWEETS AFTER she GIVES SOME to JOE.

☐ She must KEEP 2 SWEETS for herself.

☐ We KEEP 2 SWEETS for ZINZI on her red mat.

☐ The other SWEETS are for JOE.

☐ So we TAKE ALL those SWEETS AWAY and MOVE them to JOE'S mat.

☐ Now we'll COUNT HOW MANY SWEETS JOE HAS...

☐ LOOK, now JOE HAS 5 SWEETS AFTER ZINZI GIVES him SOME.

☐ So WHAT NUMBER should we circle?

☐ We will circle NUMBER 5.

AiLgS Scoring:

____ Script items used

____ AiLgS words not pointed to

____ AiLgS words omitted

____: ____ Number of Statements : Questions used

: (Statement : Question Ratio)

Checklist Legend

☑ : Tick statements if they are used on the script.

○ : Circle words that are indicated as AiLgS words (capitalized) but are not pointed to.

~~E.g.~~ : Strike words through AiLgS words (capitalized) that are not used.

: Zinzi has 8 sweets. Then she gives some to Joe. Now Zinzi has 6 sweets. How many sweets does Zinzi give to Joe?

- ☐ ZINZI HAS 8 SWEETS.
- ☐ Then, she GIVES SOME to JOE.
- ☐ Now ZINZI HAS 6 SWEETS.
- ☐ HOW MANY SWEETS does ZINZI GIVE to JOE?
- ☐ To work out this ANSWER, we must GIVE ZINZI her 8 SWEETS.
- ☐ We PUT them here on her red mat.
- ☐ Let's COUNT ZINZI'S SWEETS…
- ☐ There, now ZINZI HAS her 8 SWEETS.
- ☐ But LOOK, JOE HAS no SWEETS yet.
- ☐ He HAS NOTHING on his purple mat.
- ☐ So ZINZI is kind, she will SHARE with JOE.
- ☐ ZINZI will GIVE SOME SWEETS to JOE.
- ☐ But we DON'T KNOW HOW MANY SWEETS ZINZI GIVES to JOE, because she only says that she will GIVE him SOME.
- ☐ ZINZI TAKES SOME SWEETS and PUTS them on JOE'S mat, without telling us HOW MANY she PUTS there!
- ☐ We can FIND HOW MANY ZINZI GIVES to JOE.
- ☐ To do that we must THINK of HOW MANY ZINZI HAS AFTER she GIVES SOME SWEETS to JOE.
- ☐ Remember, ZINZI HAS 6 SWEETS AFTER she GIVES SOME to JOE.
- ☐ She must KEEP 6 SWEETS for herself.
- ☐ We KEEP 6 SWEETS for ZINZI on her red mat.
- ☐ The other SWEETS are for JOE.
- ☐ So we TAKE ALL those SWEETS AWAY and MOVE them to JOE'S mat.
- ☐ Now we'll COUNT HOW MANY SWEETS JOE HAS...
- ☐ LOOK, now JOE HAS 2 SWEETS AFTER ZINZI GIVES him SOME.
- ☐ So WHAT NUMBER should we circle?
- ☐ We will circle NUMBER 2.

AiLgS Scoring:

____ Script items used

____ AiLgS words not pointed to

____ AiLgS words omitted

____: ____ Number of Statements : Questions used

_____:_____ (Statement : Question Ratio)

Checklist Legend

☑ : Tick statements if they are used on the script.

○ : Circle words that are indicated as AiLgS words (capitalized) but are not pointed to.

~~E.g.~~ : Strike words through AiLgS words (capitalized) that are not used.

: Zinzi has 5 sweets. Then she gives some to Joe. Now Zinzi has 4 sweets. How many sweets does Zinzi give to Joe?

- ☐ ZINZI HAS 5 SWEETS.
- ☐ Then, she GIVES SOME to JOE.
- ☐ Now ZINZI HAS 4 SWEETS.
- ☐ HOW MANY SWEETS does ZINZI GIVE to JOE?
- ☐ To work out this ANSWER, we must GIVE ZINZI her 5 SWEETS.
- ☐ We PUT them here on her red mat.
- ☐ Let's COUNT ZINZI'S SWEETS…
- ☐ There, now ZINZI HAS her 5 SWEETS.
- ☐ But LOOK, JOE HAS no SWEETS yet.
- ☐ He HAS NOTHING on his purple mat.
- ☐ So ZINZI is kind, she will SHARE with JOE.
- ☐ ZINZI will GIVE SOME SWEETS to JOE.
- ☐ But we DON'T KNOW HOW MANY SWEETS ZINZI GIVES to JOE, because she only says that she will GIVE him SOME.
- ☐ ZINZI TAKES SOME SWEETS and PUTS them on JOE'S mat, without telling us HOW MANY she PUTS there!
- ☐ We can FIND HOW MANY ZINZI GIVES to JOE.
- ☐ To do that we must THINK of HOW MANY ZINZI HAS AFTER she GIVES SOME SWEETS to JOE.
- ☐ Remember, ZINZI HAS 4 SWEETS AFTER she GIVES SOME to JOE.
- ☐ She must KEEP 4 SWEETS for herself.
- ☐ We KEEP 4 SWEETS for ZINZI on her red mat.
- ☐ The other SWEETS are for JOE.
- ☐ So we TAKE ALL those SWEETS AWAY and MOVE them to JOE'S mat.
- ☐ Now we'll COUNT HOW MANY SWEETS JOE HAS...
- ☐ LOOK, now JOE HAS 1 SWEET AFTER ZINZI GIVES him SOME.
- ☐ So WHAT NUMBER should we circle?
- ☐ We will circle NUMBER 1.

AiLgS Scoring:

____ Script items used

____ AiLgS words not pointed to

____ AiLgS words omitted

____: ____ Number of Statements : Questions used

______:_____ (Statement : Question Ratio)

Checklist Legend

☑ : Tick statements if they are used on the script.

○ : Circle words that are indicated as AiLgS words (capitalized) but are not pointed to.

~~E.g.~~ : Strike words through AiLgS words (capitalized) that are not used.

✄: *Zinzi has 9 sweets. Then she gives some to Joe. Now Zinzi has 5 sweets. How many sweets does Zinzi give to Joe?*

☐ ZINZI HAS 9 SWEETS.

☐ Then, she GIVES SOME to JOE.

☐ Now ZINZI HAS 5 SWEETS.

☐ HOW MANY SWEETS does ZINZI GIVE to JOE?

☐ To work out this ANSWER, we must GIVE ZINZI her 9 SWEETS.

☐ We PUT them here on her red mat.

☐ Let's COUNT ZINZI'S SWEETS…

☐ There, now ZINZI HAS her 9 SWEETS.

☐ But LOOK, JOE HAS no SWEETS yet.

☐ He HAS NOTHING on his purple mat.

☐ So ZINZI is kind, she will SHARE with JOE.

☐ ZINZI will GIVE SOME SWEETS to JOE.

☐ But we DON'T KNOW HOW MANY SWEETS ZINZI GIVES to JOE, because she only says that she will GIVE him SOME.

☐ ZINZI TAKES SOME SWEETS and PUTS them on JOE'S mat, without telling us HOW MANY she PUTS there!

☐ We can FIND HOW MANY ZINZI GIVES to JOE.

☐ To do that we must THINK of HOW MANY ZINZI HAS AFTER she GIVES SOME SWEETS to JOE.

☐ Remember, ZINZI HAS 5 SWEETS AFTER she GIVES SOME to JOE.

☐ She must KEEP 5 SWEETS for herself.

☐ We KEEP 5 SWEETS for ZINZI on her red mat.

☐ The other SWEETS are for JOE.

☐ So we TAKE ALL those SWEETS AWAY and MOVE them to JOE'S mat.

☐ Now we'll COUNT HOW MANY SWEETS JOE HAS...

☐ LOOK, now JOE HAS 4 SWEETS AFTER ZINZI GIVES him SOME.

☐ So WHAT NUMBER should we circle?

☐ We will circle NUMBER 4.

AiLgS Scoring:

____ Script items used

____ AiLgS words not pointed to

____ AiLgS words omitted

____: ____ Number of Statements : Questions used

______:______ (Statement : Question Ratio)

Checklist Legend

☑ : Tick statements if they are used on the script.

○ : Circle words that are indicated as AiLgS words (capitalized) but are not pointed to.

~~E.g.~~ : Strike words through AiLgS words (capitalized) that are not used.

⇨: *Zinzi has 10 sweets. Then she gives some to Joe. Now Zinzi has 8 sweets. How many sweets does Zinzi give to Joe?*

☐ ZINZI HAS 10 SWEETS.

☐ Then, she GIVES SOME to JOE.

☐ Now ZINZI HAS 8 SWEETS.

☐ HOW MANY SWEETS does ZINZI GIVE to JOE?

☐ To work out this ANSWER, we must GIVE ZINZI her 10 SWEETS.

☐ We PUT them here on her red mat.

☐ Let's COUNT ZINZI'S SWEETS…

☐ There, now ZINZI HAS her 10 SWEETS.

☐ But LOOK, JOE HAS no SWEETS yet.

☐ He HAS NOTHING on his purple mat.

☐ So ZINZI is kind, she will SHARE with JOE.

☐ ZINZI will GIVE SOME SWEETS to JOE.

☐ But we DON'T KNOW HOW MANY SWEETS ZINZI GIVES to JOE, because she only says that she will GIVE him SOME.

☐ ZINZI TAKES SOME SWEETS and PUTS them on JOE'S mat, without telling us HOW MANY she PUTS there!

☐ We can FIND HOW MANY ZINZI GIVES to JOE.

☐ To do that we must THINK of HOW MANY ZINZI HAS AFTER she GIVES SOME SWEETS to JOE.

☐ Remember, ZINZI HAS 8 SWEETS AFTER she GIVES SOME to JOE.

☐ She must KEEP 8 SWEETS for herself.

☐ We KEEP 8 SWEETS for ZINZI on her red mat.

☐ The other SWEETS are for JOE.

☐ So we TAKE ALL those SWEETS AWAY and MOVE them to JOE'S mat.

☐ Now we'll COUNT HOW MANY SWEETS JOE HAS...

☐ LOOK, now JOE HAS 2 SWEETS AFTER ZINZI GIVES him SOME.

☐ So WHAT NUMBER should we circle?

☐ We will circle NUMBER 2.

AiLgS Scoring:

____ Script items used

____ AiLgS words not pointed to

____ AiLgS words omitted

____: ____ Number of Statements : Questions used

⇘_____:_____ (Statement : Question Ratio)

Checklist Legend

☑ : Tick statements if they are used on the script.

○ : Circle words that are indicated as AiLgS words (capitalized) but are not pointed to.

~~E.g.~~ : Strike words through AiLgS words (capitalized) that are not used.

👁: *Zinzi has 6 sweets. Then she gives some to Joe. Now Zinzi has 0 sweets. How many sweets does Zinzi give to Joe?*

☐ ZINZI HAS 6 SWEETS.

☐ Then, she GIVES SOME to JOE.

☐ Now ZINZI HAS 0 SWEETS.

☐ HOW MANY SWEETS does ZINZI GIVE to JOE?

☐ To work out this ANSWER, we must GIVE ZINZI her 6 SWEETS.

☐ We PUT them here on her red mat.

☐ Let's COUNT ZINZI'S SWEETS…

☐ There, now ZINZI HAS her 6 SWEETS.

☐ But LOOK, JOE HAS no SWEETS yet.

☐ He HAS NOTHING on his purple mat.

☐ So ZINZI is kind, she will SHARE with JOE.

☐ ZINZI will GIVE SOME SWEETS to JOE.

☐ But we DON'T KNOW HOW MANY SWEETS ZINZI GIVES to JOE, because she only says that she will GIVE him SOME.

☐ ZINZI TAKES SOME SWEETS and PUTS them on JOE'S mat, without telling us HOW MANY she PUTS there!

☐ We can FIND HOW MANY ZINZI GIVES to JOE.

☐ To do that we must THINK of HOW MANY ZINZI HAS AFTER she GIVES SOME SWEETS to JOE.

☐ Remember, ZINZI HAS 0 SWEETS AFTER she GIVES SOME to JOE.

☐ She must KEEP 0 SWEETS for herself.

☐ We KEEP 0 SWEETS for ZINZI on her red mat.

☐ The other SWEETS are for JOE.

☐ So we TAKE ALL those SWEETS AWAY and MOVE them to JOE'S mat.

☐ Now we'll COUNT HOW MANY SWEETS JOE HAS...

☐ LOOK, now JOE HAS 6 SWEETS AFTER ZINZI GIVES him SOME.

☐ So WHAT NUMBER should we circle?

☐ We will circle NUMBER 6.

AiLgS Scoring:

____ Script items used

____ AiLgS words not pointed to

____ AiLgS words omitted

____: ____ Number of Statements : Questions used

↳_____:_____ (Statement : Question Ratio)

Appendix AA
MAiLgS programme script checklist: Combine type

Checklist Legend

☑ : Tick statements if they are used on the script.

○ : Circle words that are indicated as AiLgS words (capitalized) but are not pointed to.

~~E.g.~~ : Strike words through AiLgS words (capitalized) that are not used.

■: *Zinzi and Joe have 9 sweets together. Zinzi has 1 sweet. How many sweets does Joe have?*

☐ To work out the ANSWER, we must let ZINZI and JOE HAVE 9 SWEETS TOGETHER.

☐ ZINZI and JOE PUT their SWEETS TOGETHER like that.

☐ Right now ZINZI HAS NOTHING and JOE also HAS NOTHING.

☐ But remember, ZINZI must HAVE 1 SWEET.

☐ So we must PUT that SWEET here on her red mat.

☐ That means we have to TAKE ZINZI'S 1 SWEET AWAY and PUT it here.

☐ Now LOOK, there are LESS SWEETS here.

☐ But what about poor JOE? He still HAS NOTHING.

☐ I'm sure that he would also like SOME SWEETS.

☐ Wait a bit, we can GIVE SOME SWEETS to JOE!

☐ He can HAVE ALL these SWEETS because ZINZI already has HER SWEETS.

☐ So, we will MOVE ALL the SWEETS to JOE like that.

☐ ALL the SWEETS are FINISHED here so now we should COUNT HOW MANY SWEETS we GIVE to JOE...

☐ Now we KNOW that JOE HAS 8 SWEETS.

☐ So WHAT NUMBER must we circle?

☐ Yes, we circle NUMBER 8.

AiLgS Scoring:

____ Script items used

____ AiLgS words not pointed to

____ AiLgS words omitted

____: ____ Number of Statements : Questions used

✎______:______ (Statement : Question Ratio)

Checklist Legend

☑ : Tick statements if they are used on the script.

○ : Circle words that are indicated as AiLgS words (capitalized) but are not pointed to.

~~E.g.~~ : Strike words through AiLgS words (capitalized) that are not used.

: Zinzi and Joe have 8 sweets together. Zinzi has 3 sweets. How many sweets does Joe have?

☐ To work out the ANSWER, we must let ZINZI and JOE HAVE 8 SWEETS TOGETHER.

☐ ZINZI and JOE PUT their SWEETS TOGETHER like that.

☐ Right now ZINZI HAS NOTHING and JOE also HAS NOTHING.

☐ But remember, ZINZI must HAVE 3 SWEETS.

☐ So we must PUT those SWEETS here on her red mat.

☐ That means we have to TAKE ZINZI'S 3 SWEETS AWAY and PUT them here.

☐ Now LOOK, there are LESS SWEETS here.

☐ But what about poor JOE? He still HAS NOTHING.

☐ I'm sure that he would also like SOME SWEETS.

☐ Wait a bit, we can GIVE SOME SWEETS to JOE!

☐ He can HAVE ALL these SWEETS because ZINZI already has HER SWEETS.

☐ So, we will MOVE ALL the SWEETS to JOE like that.

☐ ALL the SWEETS are FINISHED here so now we should COUNT HOW MANY SWEETS we GIVE to JOE...

☐ Now we KNOW that JOE HAS 5 SWEETS.

☐ So WHAT NUMBER must we circle?

☐ Yes, we circle NUMBER 5.

AiLgS Scoring:

____ Script items used

____ AiLgS words not pointed to

____ AiLgS words omitted

____: ____ Number of Statements : Questions used

______:_____ (Statement : Question Ratio)

Checklist Legend

☑ : Tick statements if they are used on the script.

○ : Circle words that are indicated as AiLgS words (capitalized) but are not pointed to.

~~E.g.~~ : Strike words through AiLgS words (capitalized) that are not used.

: Zinzi and Joe have 6 sweets together. Zinzi has 5 sweets. How many sweets does Joe have?

☐ To work out the ANSWER, we must let ZINZI and JOE HAVE 6 SWEETS TOGETHER.

☐ ZINZI and JOE PUT their SWEETS TOGETHER like that.

☐ Right now ZINZI HAS NOTHING and JOE also HAS NOTHING.

☐ But remember, ZINZI must HAVE 5 SWEETS.

☐ So we must PUT those SWEETS here on her red mat.

☐ That means we have to TAKE ZINZI'S 5 SWEETS AWAY and PUT them here.

☐ Now LOOK, there are LESS SWEETS here.

☐ But what about poor JOE? He still HAS NOTHING.

☐ I'm sure that he would also like SOME SWEETS.

☐ Wait a bit, we can GIVE SOME SWEETS to JOE!

☐ He can HAVE ALL these SWEETS because ZINZI already has HER SWEETS.

☐ So, we will MOVE ALL the SWEETS to JOE like that.

☐ ALL the SWEETS are FINISHED here so now we should COUNT HOW MANY SWEETS we GIVE to JOE...

☐ Now we KNOW that JOE HAS 1 SWEET.

☐ So WHAT NUMBER must we circle?

☐ Yes, we circle NUMBER 1.

AiLgS Scoring:

____ Script items used

____ AiLgS words not pointed to

____ AiLgS words omitted

____: ____ Number of Statements : Questions used

_____:_____ (Statement : Question Ratio)

Checklist Legend
☑ : Tick statements if they are used on the script.
○ : Circle words that are indicated as AiLgS words (capitalized) but are not pointed to.
~~E.g.~~ : Strike words through AiLgS words (capitalized) that are not used.

✓: Zinzi and Joe have 9 sweets together. Zinzi has 3 sweets. How many sweets does Joe have?

☐ To work out the ANSWER, we must let ZINZI and JOE HAVE 9 SWEETS TOGETHER.
☐ ZINZI and JOE PUT their SWEETS TOGETHER like that.
☐ Right now ZINZI HAS NOTHING and JOE also HAS NOTHING.
☐ But remember, ZINZI must HAVE 3 SWEETS.
☐ So we must PUT those SWEETS here on her red mat.
☐ That means we have to TAKE ZINZI'S 3 SWEETS AWAY and PUT them here.
☐ Now LOOK, there are LESS SWEETS here.
☐ But what about poor JOE? He still HAS NOTHING.
☐ I'm sure that he would also like SOME SWEETS.
☐ Wait a bit, we can GIVE SOME SWEETS to JOE!
☐ He can HAVE ALL these SWEETS because ZINZI already has HER SWEETS.
☐ So, we will MOVE ALL the SWEETS to JOE like that.
☐ ALL the SWEETS are FINISHED here so now we should COUNT HOW MANY SWEETS we GIVE to JOE...
☐ Now we KNOW that JOE HAS 6 SWEET.
☐ So WHAT NUMBER must we circle?
☐ Yes, we circle NUMBER 6.

AiLgS Scoring:
____ Script items used
____ AiLgS words not pointed to
____ AiLgS words omitted
____: ____ Number of Statements : Questions used
↳ _____:_____ (Statement : Question Ratio)

Checklist Legend

☑ : Tick statements if they are used on the script.

○ : Circle words that are indicated as AiLgS words (capitalized) but are not pointed to.

~~E.g.~~ : Strike words through AiLgS words (capitalized) that are not used.

: Zinzi and Joe have 10 sweets together. Zinzi has 1 sweet. How many sweets does Joe have?

☐ To work out the ANSWER, we must let ZINZI and JOE HAVE 10 SWEETS TOGETHER.

☐ ZINZI and JOE PUT their SWEETS TOGETHER like that.

☐ Right now ZINZI HAS NOTHING and JOE also HAS NOTHING.

☐ But remember, ZINZI must HAVE 1 SWEET.

☐ So we must PUT that SWEET here on her red mat.

☐ That means we have to TAKE ZINZI'S 1 SWEET AWAY and PUT it here.

☐ Now LOOK, there are LESS SWEETS here.

☐ But what about poor JOE? He still HAS NOTHING.

☐ I'm sure that he would also like SOME SWEETS.

☐ Wait a bit, we can GIVE SOME SWEETS to JOE!

☐ He can HAVE ALL these SWEETS because ZINZI already has HER SWEETS.

☐ So, we will MOVE ALL the SWEETS to JOE like that.

☐ ALL the SWEETS are FINISHED here so now we should COUNT HOW MANY SWEETS we GIVE to JOE...

☐ Now we KNOW that JOE HAS 9 SWEETS.

☐ So WHAT NUMBER must we circle?

☐ Yes, we circle NUMBER 9.

AiLgS Scoring:

____ Script items used

____ AiLgS words not pointed to

____ AiLgS words omitted

____: ____ Number of Statements : Questions used

______:______ (Statement : Question Ratio)

Checklist Legend

☑ : Tick statements if they are used on the script.

○ : Circle words that are indicated as AiLgS words (capitalized) but are not pointed to.

~~E.g.~~ : Strike words through AiLgS words (capitalized) that are not used.

: Zinzi and Joe have 5 sweets together. Zinzi has 2 sweets. How many sweets does Joe have?

☐ To work out the ANSWER, we must let ZINZI and JOE HAVE 5 SWEETS TOGETHER.

☐ ZINZI and JOE PUT their SWEETS TOGETHER like that.

☐ Right now ZINZI HAS NOTHING and JOE also HAS NOTHING.

☐ But remember, ZINZI must HAVE 2 SWEETS.

☐ So we must PUT those SWEETS here on her red mat.

☐ That means we have to TAKE ZINZI'S 2 SWEETS AWAY and PUT them here.

☐ Now LOOK, there are LESS SWEETS here.

☐ But what about poor JOE? He still HAS NOTHING.

☐ I'm sure that he would also like SOME SWEETS.

☐ Wait a bit, we can GIVE SOME SWEETS to JOE!

☐ He can HAVE ALL these SWEETS because ZINZI already has HER SWEETS.

☐ So, we will MOVE ALL the SWEETS to JOE like that.

☐ ALL the SWEETS are FINISHED here so now we should COUNT HOW MANY SWEETS we GIVE to JOE...

☐ Now we KNOW that JOE HAS 3 SWEETS.

☐ So WHAT NUMBER must we circle?

☐ Yes, we circle NUMBER 3.

AiLgS Scoring:

____ Script items used

____ AiLgS words not pointed to

____ AiLgS words omitted

____: ____ Number of Statements : Questions used

______:______ (Statement : Question Ratio)

Appendix AB
MAiLgS programme script checklist: Compare type

Checklist Legend

☑ : Tick statements if they are used on the script.

○ : Circle words that are indicated as AiLgS words (capitalized) but are not pointed to.

~~E.g.~~ : Strike words through AiLgS words (capitalized) that are not used.

: Zinzi has 3 sweets. Joe has 2 sweets. How many sweets does Joe have less than Zinzi?

☐ To work out this ANSWER, we must GIVE ZINZI her 3 SWEETS.
☐ We must PUT them here on her red mat.
☐ And JOE HAS 2 SWEETS.
☐ We must PUT them here on his purple mat.
☐ But if you LOOK, ZINZI and JOE don't HAVE the SAME NUMBER of SWEETS.
☐ Their NUMBER of SWEETS is DIFFERENT.
☐ ZINZI HAS MANY SWEETS.
☐ ZINZI HAS MORE SWEETS than JOE because she HAS 3.
☐ JOE HAS FEW SWEETS.
☐ JOE HAS LESS SWEETS than ZINZI because he HAS 2.
☐ To FIND HOW MANY SWEETS JOE HAS LESS than ZINZI.
☐ We must LOOK HOW MANY SWEETS are the SAME.
☐ We must FIND which SWEETS match.
☐ These SWEETS match, these SWEETS match…ALL these SWEETS to here match.
☐ Now ALL the SWEETS by JOE are FINISHED.
☐ These SWEETS for ZINZI don't HAVE SWEETS by JOE to match.
☐ So that means for ALL these SWEETS JOE HAS LESS than ZINZI because he does not HAVE enough SWEETS to match hers.
☐ AFTER we match the SAME SWEETS, these are the SWEETS that JOE HAS LESS than ZINZI.
☐ Let's COUNT them…
☐ So JOE HAS 1 SWEET LESS than ZINZI.
☐ WHAT NUMBER should we circle?
☐ We are going to circle NUMBER 1 on the answer sheet.

AiLgS Scoring:

____ Script items used

____ AiLgS words not pointed to

____ AiLgS words omitted

____: ____ Number of Statements : Questions used

_____:_____ (Statement : Question Ratio)

Checklist Legend

☑ : Tick statements if they are used on the script.

○ : Circle words that are indicated as AiLgS words (capitalized) but are not pointed to.

~~E.g.~~ : Strike words through AiLgS words (capitalized) that are not used.

? : *Zinzi has 8 sweets. Joe has 1 sweet. How many sweets does Joe have less than Zinzi?*

- ☐ To work out this ANSWER, we must GIVE ZINZI her 8 SWEETS.
- ☐ We must PUT them here on her red mat.
- ☐ And JOE HAS 1 SWEET.
- ☐ We must PUT it here on his purple mat.
- ☐ But if you LOOK, ZINZI and JOE don't HAVE the SAME NUMBER of SWEETS.
- ☐ Their NUMBER of SWEETS is DIFFERENT.
- ☐ ZINZI HAS MANY SWEETS.
- ☐ ZINZI HAS MORE SWEETS than JOE because she HAS 8.
- ☐ JOE HAS FEW SWEETS.
- ☐ JOE HAS LESS SWEETS than ZINZI because he HAS 1.
- ☐ To FIND HOW MANY SWEETS JOE HAS LESS than ZINZI.
- ☐ We must LOOK HOW MANY SWEETS are the SAME.
- ☐ We must FIND which SWEETS match.
- ☐ These SWEETS match, these SWEETS match…ALL these SWEETS to here match.
- ☐ Now ALL the SWEETS by JOE are FINISHED.
- ☐ These SWEETS for ZINZI don't HAVE SWEETS by JOE to match.
- ☐ So that means for ALL these SWEETS JOE HAS LESS than ZINZI because he does not HAVE enough SWEETS to match hers.
- ☐ AFTER we match the SAME SWEETS, these are the SWEETS that JOE HAS LESS than ZINZI.
- ☐ Let's COUNT them…
- ☐ So JOE HAS 7 SWEETS LESS than ZINZI.
- ☐ WHAT NUMBER should we circle?
- ☐ We are going to circle NUMBER 7 on the answer sheet.

AiLgS Scoring:

____ Script items used

____ AiLgS words not pointed to

____ AiLgS words omitted

____: ____ Number of Statements : Questions used

✎_____:_____ (Statement : Question Ratio)

Checklist Legend

☑ : Tick statements if they are used on the script.

○ : Circle words that are indicated as AiLgS words (capitalized) but are not pointed to.

~~E.g.~~ : Strike words through AiLgS words (capitalized) that are not used.

: Zinzi has 10 sweets. Joe has 4 sweets. How many sweets does Joe have less than Zinzi?

- ☐ To work out this ANSWER, we must GIVE ZINZI her 10 SWEETS.
- ☐ We must PUT them here on her red mat.
- ☐ And JOE HAS 4 SWEETS.
- ☐ We must PUT them here on his purple mat.
- ☐ But if you LOOK, ZINZI and JOE don't HAVE the SAME NUMBER of SWEETS.
- ☐ Their NUMBER of SWEETS is DIFFERENT.
- ☐ ZINZI HAS MANY SWEETS.
- ☐ ZINZI HAS MORE SWEETS than JOE because she HAS 10.
- ☐ JOE HAS FEW SWEETS.
- ☐ JOE HAS LESS SWEETS than ZINZI because he HAS 4.
- ☐ To FIND HOW MANY SWEETS JOE HAS LESS than ZINZI.
- ☐ We must LOOK HOW MANY SWEETS are the SAME.
- ☐ We must FIND which SWEETS match.
- ☐ These SWEETS match, these SWEETS match…ALL these SWEETS to here match.
- ☐ Now ALL the SWEETS by JOE are FINISHED.
- ☐ These SWEETS for ZINZI don't HAVE SWEETS by JOE to match.
- ☐ So that means for ALL these SWEETS JOE HAS LESS than ZINZI because he does not HAVE enough SWEETS to match hers.
- ☐ AFTER we match the SAME SWEETS, these are the SWEETS that JOE HAS LESS than ZINZI.
- ☐ Let's COUNT them…
- ☐ So JOE HAS 6 SWEET LESS than ZINZI.
- ☐ WHAT NUMBER should we circle?
- ☐ We are going to circle NUMBER 6 on the answer sheet.

AiLgS Scoring:

____ Script items used

____ AiLgS words not pointed to

____ AiLgS words omitted

____: ____ Number of Statements : Questions used

______:______ (Statement : Question Ratio)

Checklist Legend

☑ : Tick statements if they are used on the script.

○ : Circle words that are indicated as AiLgS words (capitalized) but are not pointed to.

~~E.g.~~ : Strike words through AiLgS words (capitalized) that are not used.

♦: *Zinzi has 7 sweets. Joe has 3 sweets. How many sweets does Joe have less than Zinzi?*

☐ To work out this ANSWER, we must GIVE ZINZI her 7 SWEETS.
☐ We must PUT them here on her red mat.
☐ And JOE HAS 3 SWEETS.
☐ We must PUT them here on his purple mat.
☐ But if you LOOK, ZINZI and JOE don't HAVE the SAME NUMBER of SWEETS.
☐ Their NUMBER of SWEETS is DIFFERENT.
☐ ZINZI HAS MANY SWEETS.
☐ ZINZI HAS MORE SWEETS than JOE because she HAS 7.
☐ JOE HAS FEW SWEETS.
☐ JOE HAS LESS SWEETS than ZINZI because he HAS 3.
☐ To FIND HOW MANY SWEETS JOE HAS LESS than ZINZI.
☐ We must LOOK HOW MANY SWEETS are the SAME.
☐ We must FIND which SWEETS match.
☐ These SWEETS match, these SWEETS match…ALL these SWEETS to here match.
☐ Now ALL the SWEETS by JOE are FINISHED.
☐ These SWEETS for ZINZI don't HAVE SWEETS by JOE to match.
☐ So that means for ALL these SWEETS JOE HAS LESS than ZINZI because he does not HAVE enough SWEETS to match hers.
☐ AFTER we match the SAME SWEETS, these are the SWEETS that JOE HAS LESS than ZINZI.
☐ Let's COUNT them…
☐ So JOE HAS 4 SWEET LESS than ZINZI.
☐ WHAT NUMBER should we circle?
☐ We are going to circle NUMBER 4 on the answer sheet.

AiLgS Scoring:

____ Script items used

____ AiLgS words not pointed to

____ AiLgS words omitted

____: ____ Number of Statements : Questions used

✎_____:_____ (Statement : Question Ratio)

Checklist Legend

☑ : Tick statements if they are used on the script.

○ : Circle words that are indicated as AiLgS words (capitalized) but are not pointed to.

~~E.g.~~ : Strike words through AiLgS words (capitalized) that are not used.

: Zinzi has 5 sweets. Joe has 3 sweets. How many sweets does Joe have less than Zinzi?

☐ To work out this ANSWER, we must GIVE ZINZI her 5 SWEETS.
☐ We must PUT them here on her red mat.
☐ And JOE HAS 3 SWEETS.
☐ We must PUT them here on his purple mat.
☐ But if you LOOK, ZINZI and JOE don't HAVE the SAME NUMBER of SWEETS.
☐ Their NUMBER of SWEETS is DIFFERENT.
☐ ZINZI HAS MANY SWEETS.
☐ ZINZI HAS MORE SWEETS than JOE because she HAS 5.
☐ JOE HAS FEW SWEETS.
☐ JOE HAS LESS SWEETS than ZINZI because he HAS 3.
☐ To FIND HOW MANY SWEETS JOE HAS LESS than ZINZI.
☐ We must LOOK HOW MANY SWEETS are the SAME.
☐ We must FIND which SWEETS match.
☐ These SWEETS match, these SWEETS match…ALL these SWEETS to here match.
☐ Now ALL the SWEETS by JOE are FINISHED.
☐ These SWEETS for ZINZI don't HAVE SWEETS by JOE to match.
☐ So that means for ALL these SWEETS JOE HAS LESS than ZINZI because he does not HAVE enough SWEETS to match hers.
☐ AFTER we match the SAME SWEETS, these are the SWEETS that JOE HAS LESS than ZINZI.
☐ Let's COUNT them…
☐ So JOE HAS 2 SWEETS LESS than ZINZI.
☐ WHAT NUMBER should we circle?
☐ We are going to circle NUMBER 2 on the answer sheet.

AiLgS Scoring:

____ Script items used

____ AiLgS words not pointed to

____ AiLgS words omitted

____: ____ Number of Statements : Questions used

_____:_____ (Statement : Question Ratio)

Checklist Legend

☑ : Tick statements if they are used on the script.

○ : Circle words that are indicated as AiLgS words (capitalized) but are not pointed to.

~~E.g.~~ : Strike words through AiLgS words (capitalized) that are not used.

: *Zinzi has 4 sweets. Joe has 1 sweet. How many sweets does Joe have less than Zinzi?*

☐ To work out this ANSWER, we must GIVE ZINZI her 4 SWEETS.
☐ We must PUT them here on her red mat.
☐ And JOE HAS 1 SWEET.
☐ We must PUT it here on his purple mat.
☐ But if you LOOK, ZINZI and JOE don't HAVE the SAME NUMBER of SWEETS.
☐ Their NUMBER of SWEETS is DIFFERENT.
☐ ZINZI HAS MANY SWEETS.
☐ ZINZI HAS MORE SWEETS than JOE because she HAS 4.
☐ JOE HAS FEW SWEETS.
☐ JOE HAS LESS SWEETS than ZINZI because he HAS 1.
☐ To FIND HOW MANY SWEETS JOE HAS LESS than ZINZI.
☐ We must LOOK HOW MANY SWEETS are the SAME.
☐ We must FIND which SWEETS match.
☐ These SWEETS match, these SWEETS match…ALL these SWEETS to here match.
☐ Now ALL the SWEETS by JOE are FINISHED.
☐ These SWEETS for ZINZI don't HAVE SWEETS by JOE to match.
☐ So that means for ALL these SWEETS JOE HAS LESS than ZINZI because he does not HAVE enough SWEETS to match hers.
☐ AFTER we match the SAME SWEETS, these are the SWEETS that JOE HAS LESS than ZINZI.
☐ Let's COUNT them…
☐ So JOE HAS 3 SWEETS LESS than ZINZI.
☐ WHAT NUMBER should we circle?
☐ We are going to circle NUMBER 3 on the answer sheet.

AiLgS Scoring:

____ Script items used

____ AiLgS words not pointed to

____ AiLgS words omitted

____: ____ Number of Statements : Questions used

_____:_____ (Statement : Question Ratio)