Solving Mathematical Word Problems Using Passively Received Visualisation (PRV) and Self-constructed Visualisation (SCV): The Case of Primary School Students with Attention Deficit Hyperactivity Disorder (ADHD) in Kuwait

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Declaration of Originality

I affirm that this dissertation in its totality is the result of my own work and includes nothing which is the outcome of work done in collaboration except where specifically indicated in the text.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

This intervention study sets out to explore the impact of visualisation on (1) helping to make mathematical word problem-solving more accessible to students with attention deficit hyperactivity disorder (ADHD) and (2) helping these students become more focused during the word problem-solving task. Specifically, the study examines the impact of two types of visualisation: passively received visualisation (PRV), which refers to given images or visual representations of mathematical ideas found in word problems (for example, three groups of five apples) and self-constructed visualisation (SCV), which refers to images or visual representations of mathematical ideas relating to word problems that students have to come up with themselves. The rationale for comparing the effect of these two visualisation approaches is to test Papert's theory of constructionism, where the externalisation or projecting out of students' current understanding to the outside world is deemed to be a more effective way of learning. The study adopted the sequential explanatory mixed methods design. The sample size was 20 9-11 year-old students (8 female, 12 male), who had been diagnosed with ADHD across two special needs schools in Kuwait. The students were randomly and equally divided into two groups (PRV and SCV). Each student across the two groups attended 20 daily 30-minute one-to-one sessions, where they were asked to solve mathematical word problems. These sessions were conducted by the current study researcher. Depending on the group to which they were assigned, the students solved the problems either by using images and visual representations of mathematical ideas that accompanied the problems (PRV), or by drawing images and visual representations of mathematical ideas found in the problems themselves (SCV). The students took a pre-test, post-test, and delayed post-test (taken one month after the end of the intervention). They also completed four interim tests during the intervention period (one test every five sessions) to allow the researchers to closely monitor the impact (if any) of the PRV and SCV approaches. Furthermore, in order to explore the extent to which PRV and SCV help students with ADHD remain focused while solving mathematical word problems, a series of structured (quantitative) observations was conducted. The observations monitored the frequency of ADHD behaviour occurrences, demonstrated by each student in their 20 one-to-one sessions. The observations focused on three specific ADHD behaviours (hyperactivity, impulsivity, and inattention) as conceptualised by the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5). Additionally, the students' and teachers' perceptions were collected in this study to provide more in-depth understanding about the impact of using SCV and PRV on ADHD students' mathematical word problem solving ability and their behaviour. The significance of the current study is that it is one of the first few empirical studies to test the validity of Papert's theory of constructionism, particularly in relation to the role of externalisation. More practically, the study sheds light on the extent to which SCV could meet the unique mathematical learning needs of students with special needs like ADHD. The results reveal that there were no statistically significant differences in using SCV to solve mathematical word problems compared to PRV. Similar results were obtained for the students' behaviour. Both sets of results were confirmed by students' and teachers' perceptions.

CHAPTER 1: INTRODUCTION

1.1 Research Rationale

1.1.1 Inclusive Education and Attention Deficit and Hyperactive Disorder (ADHD)

Inclusive education involves support for all students in their learning, while promoting their participation in every aspect of school life (Loreman, Deppeler, & Harvey, 2005; Ofsted, 2006). The concept of inclusive education was first introduced in the literature of Western countries (Europe and the USA) in the early 1980s, in the context of the perceived exclusion of disabled learners by placing them in special schools (Opretti & Belalcazar, 2008). Therefore, the notion of inclusion is based on ensuring that all students have the same educational opportunities, and that educational justice can be achieved for all segments of society (Polat, 2011). However, the literature does not provide just one definition of inclusive education; most authors refer to the provision of equal educational opportunities for every student, especially for those with special educational needs (SEN). Similarly, Daniela and Lytras (2018) emphasise that inclusion is important for understanding the needs of students with specific educational requirements, in order to provide them with suitable support in light of their disabilities. Furthermore, according to some studies, such as Tennant and Foley (2013), inclusive atmospheres created by teachers are helpful for learners, because inclusive education increases teachers' ability to engage all children concurrently and positively.

An inclusion system is based on the assumption that students with special educational needs (SEN) can be accommodated by the instructor giving them adequate attention, resulting in their improved schooling performance (Alkhateeb, Hadidi, & Alkhateeb, 2015). As the current research study focused in schooling and education in Kuwait, according to Kuwait's Ministry of Education

(2006a), three categories of SEN students are included in Ministry schools: children with Down's syndrome, and children with other learning disabilities (for example, dyslexia, dyscalculia, and attention deficit and hyperactive disorder [ADHD]). Weber (2012) explains that Kuwait has adopted an inclusive education system as part of a broader national strategy, because it is implied in the religious mandate that forms a significant part of the policy-making process in the region. Al-Manabri, Al-Sharhan, Elbeheri, Jasem and Everatt (2013) also highlight that inclusive education is part of Kuwaiti mainstream education, which is one of the strategies through which learning institutions provide equal opportunities for all children.

However, the implementation of inclusive education to accommodate SEN students is often negatively perceived by learning institutions and communities in the Middle East, including in Kuwait (Aldaihani, 2011). For example, Al-Manabri et al. (2013) cite a study in which SEN students were perceived in the Arab world as holding the rest of the class back, delaying the progress of learning, and asking inappropriate or irrelevant questions. Therefore, the Kuwait Ministry of Education opened two special schools for students with learning disabilities (a boys' school in 2013 and a girls' school in 2014), specifically for students with dyslexia, dyscalculia and ADHD, where the inclusion system appeared to have failed.

This current study focuses solely on ADHD, where ADHD is considered as a specific category of SEN (Hodkinson, 2016). Since ADHD has a negative influence on behaviour functioning and educational development (Lipka, Forkosh Baruch, & Meer, 2019), these students experience learning difficulties that require special educational support. Moreover, according to Sadek (2019), it is often challenging to teach students with ADHD, because they usually have more than one specific learning disability, especially in connection with literacy and mathematics. Therefore, one goal of this current study is to provide learning strategies to help students with

ADHD participate in inclusive education within one of these learning areas (mathematics), so that they can attain an equal footing with their peers.

ADHD is a hereditary disorder that is common in children (Young & Smith, 2017). It is an intelligence-based syndrome that affects an individual's abilities in terms of specific brain functions and behaviour (Young & Smith, 2017; Evans, Ling, Hill, Rinehart, Austin & Sciberras, 2018), and is mainly characterised by inattention, hyperactivity and impulsivity (Evans et al., 2018; Neudecker, Mewes, Reimers, & Woll, 2019; Xue, Zhang, & Huang, 2019). According to Young and Smith (2017), Evans et al. (2018), and Neudecker et al. (2019), ADHD manifests in 5.29% to 7.1% of school children, globally.

ADHD syndrome affects the brain's executive functions in a manner that impedes an individual's ability to organise him or herself (Evans et al., 2018), focus, apply functional memory, and perform other tasks that require executive skills (Neudecker et al., 2019; see more discussion on this in subsection 2.7.1). The condition arises from disparities in the development of the brain's anatomy, leading to challenges to social interaction and educational development. According to Schultz (2011), although ADHD is perceived to be similar to attention deficit disorder (ADD), the absence of hyperactivity in ADD implies that ADHD sufferers have other special needs, due to the impulsive nature that can accompany their inattentiveness. Additionally, there are different types of ADHD, depending on the symptoms. Correspondingly, Neudecker et al. (2019) and Woolfson (2011) identify three types of ADHD, based on American Psychiatric Publishing (2013). The first of these is ADHD-I, which is evidenced by inattention. Meanwhile, ADHD-H/I is indicated by both hyperactivity and impulsivity, and ADHD-C is a combination of all the above symptoms (inattention, hyperactivity and impulsivity).

1.1.2 Mathematics Learning and ADHD Students

In Kuwait's modern society, mathematics is recognised as an important subject, since it relates to many fields of knowledge and reflects different aspects of people's lives (Dowker, 2001; Barbara, 2015). Skovsmose (2013) defines mathematics as the science of numbers and the operationalisation of the world's numerical representation, while Vinner (2013) adds that mathematics is directly connected to all life paths and disciplines. These two statements reflect that mathematics is integrated into every aspect of life. In addition, it introduces the concept of accuracy, achieved in a logical and systematic manner, since mathematics comprise the science of quantity, quality, magnitude and measurement.

To elaborate on the above, the subject of mathematics is complex, due to the extensive nature of the philosophies on which it is built. In turn, these are reflected in society in diverse ways (Sindhu, 2006). The application of mathematics in everyday life is therefore constantly increasing, and its specificity and complexity continue to grow. In particular, the prominent civilisations of the 20th and 21st centuries have emphasised the value of mathematical knowledge, along with other sciences (Sindhu, 2006). As a result, an unexpected association has been established between mathematics, power and global dominance, leading some societies to make changes to their political and socio-cultural norms (Dowker, 2001). Consequently, an orientation towards knowledge and proficiency in mathematics, at both individual and societal levels, has resulted in improved capabilities in social, cultural, political and economic dimensions, considered as the components of modernisation (Dowker, 2001).

In societies where mathematics and mathematicians are held in high regard, such as Japan, Singapore and South Korea, mathematics is often viewed as the foundation of their social structure

(Stevenson, Hofer & Randel, 2000). In addition, mathematics provides a logical and critical approach to conceptualising the most challenging aspects of life as we know it and can provide solutions to most of these challenges. Furthermore, mathematics can establish a foundation for future development (Stevenson et al., 2000).

Since mathematical word problems – the main area of mathematics learning addressed in this study – involve multiple thinking processes, such as understanding mathematical structures, situations, actions, analyses and reasoning (Csíkos, Szitányi, & Kelemen, 2011), mathematics word problems comprise one of the most difficult mathematical problems to solve. As the current researcher is a mathematics teacher in a learning disability school in Kuwait, she is familiar with the problems faced when presenting mathematical word problems to students with learning disabilities, especially students with ADHD. When she asked other teachers in the school if they faced the same problem, they all admitted that they did, and that there was a serious issue with word problems in mathematics, specifically for ADHD students.

Students with ADHD mainly exhibit reading disabilities (Kofler, Spiegel, Soto, Irwin, Wells, & Austin, 2018). Thus, they can face major problems with mathematical word problems, because mathematical word problems require language and reading skills (Alt, Arizmendi, & Beal, 2014; Ernest, 2011). Trakulphadetkrai, Courtney, Clenton, Treffers-Daller and Tsakalaki (2017) highlight that the difficulties involved in solving mathematical word problems are linked with limited reading comprehension and vocabulary abilities. Therefore, the aim of the current research was to try and make mathematical word problems more accessible for ADHD students to solve by looking at different types of visualisation, as discussed in the following subsection and in Chapter 2.

Regarding the education of ADHD students in mathematics, several possibilities have been proposed for implementing inclusive education. Moreira and Manrique (2014) suggest that teachers include intensive but brief interventions (for example, computer games, use of ICT, visual aids), in order to build students' comparison and counting skills. Healy and Santos (2014) also propose the use of diverse illustrations and varying speeds of delivery in skills instruction, with a repetitive training approach. Similarly, Fernandes and Healy (2014) emphasise the use of abstraction via commonly available items, such as animals, or a variety of stimuli. This current study has attempted to implement visualisation as a means of helping ADHD students acquire mathematics skills more effectively (see subsection 1.1.3), whereupon two types of visualisation were tested: *self-constructed visualisation* (SCV) and *passively received visualisation* (PRV) (for more information on these two types of visualisation, see Chapter 2). The objective of using visualization in the current study was to try and understand which types of visualisation are most effective for enhancing mathematical ability amongst ADHD learners when solving mathematical word problems.

1.1.3 The Role of Visualisation in Mathematics Learning

Visualisation refers to the ability to represent a situation, objective or set of information in a graphical or visual way, in order to facilitate the formation of conceptual images of the item, which will then serve as a reference (Arcavi, 2003). According to Hanna and Villiers (2012), visualisation is useful for creating models and addressing the challenges faced by students when seeking to acquire mathematical skills. For example, giving the student a picture or make them create a drawing can help explain a problem and make sense of it. This is because given images or drawing will enable students to access higher levels of reasoning, thereby increasing the extent to which they engage in the learning process (Hanna & Villiers, 2012).

The use of visualisation, whether for learning or teaching mathematics, has several advantages. For example, visualisation helps accelerate understanding by giving meaning to abstract problems, such as verbal or word problems (Hanna & Villiers, 2012; Bruter, 2013). In addition, visualisation helps embed more robust memories, because concrete images are easier to recall (Bruter, 2013). It also simplifies the constituent words in mathematical word problems by representing verbal relationships in a visual manner; enabling students to better understand mathematical concepts (Bruter, 2013). Likewise, the diverse learning tools integrated into the visualisation process can generate specific abilities by mapping mathematical concepts, constructing visualisation through drawing, and using images. Thus, students are helped to develop their mathematical ability, so that they can understand mathematical word problems (Hanna & Villiers, 2012).

Visualisation is crucial to mathematics learning, because it supports the thinking process – the process through which objective evaluation and the analysis of a mathematical problem take place to form a judgment (Arcavi, 2003). Furthermore, it can entail an intellectual process in which skilful and active conceptualisation is applied to the analysis, synthesis and evaluation of information acquired from observations, reasoning, reflection or communication. In addition, visualisation can systematically enhance the clarity of patterns and themes, thereby enhancing the perceptibility of the skills being taught (Dur, 2014). Based on the above, the motive for conducting the current study was the belief that visualisation can help ADHD students solve mathematical word problems more effectively. This involves using visualisation to translate words into visual form, while attempting to solve mathematical word problems.

1.1.4 Introduction to Constructionist Theory

The underpinning theory of the current study is constructionism, which will be fully discussed in the next chapter. Here, it is enough to briefly state that constructionism stems from a constructivist starting point but offers a nuanced divergence from it (Halpenny & Pettersen, 2014). Constructivism, of which Piaget was a pioneer, is a psychological theory of learning, which maintains that the way in which children develop cognitive abilities will differ according to the child. Under constructivism, children construct their own knowledge and understanding, based on their experiences (Halpenny & Pettersen, 2014). In the development of constructivism, Papert (1993), a computer scientist, proposed his theory of constructionism to underpin new teaching technology, designed to facilitate children's learning; for example, in relation to programming methods.

The focus of constructionist theory is externalisation, which refers to the ability to project out thoughts and ideas through the use of *public artefacts*. In the current study, this involves making drawings. Public artefacts can help learners gain knowledge and develop new ideas, especially "felicitously when […] supported by construction of a more public sort in the world" (Papert, 1993, p.142). According to Papert (1993), these public artefacts can be as diverse as techniques for building a sandcastle or knowledge of the universe. The theory of constructionism broadly underpins the current study, providing a lens through which to examine mathematics learning. Papert's ideas support this study's unique interpretation of the ways in which students learn to solve mathematical word problems more effectively through SCV (i.e. learners creating their own images and drawings) as compared to PRV (i.e. where the visualisation of the mathematical word problems are provided to learners).

1.2 Context: Primary Mathematics Education in Kuwait

Kuwait's education system was established in recognition of the fact that mathematics has a cumulative structure, meaning that the subsequent acquisition of competence and knowledge is dependent on the robustness of the prevailing knowledge (Ahmad & Spencer, 2017). As a result, the primary stage serves to establish foundational rules, concepts, theories and processes for achieving future competence in mathematics, whereby problem-solving skills and the operationalisation of numbers, figures and symbols are acquired (Ahmad & Spencer, 2017). Kuwait's education system, under the authority of the Ministry of Education, has experienced significant changes to features of its curriculum, mainly driven by developments in the nation's social norms, such as adjustments to expectations, introduction of philosophies of learning, and students' readiness and capabilities (Al-Duwaila, 2012). However, the main objective of Kuwait's education system is to provide sufficient education to all children, regardless of their socio-economic status, cultural background, gender, age or special needs (Ebrahim, 2012).

The various stages of Kuwaiti education represent progress based on the complexity of the content being taught (Al-Duwaila, 2012). Children in primary schools in Kuwait study mathematics on a daily basis for an average of one hour a day (Al-Duwaila, 2012). Al-Duwaila, (2012) specifies that this mathematics curriculum includes four key fields: algebra, arithmetic, geometry and mathematical analysis. According to Alhashem and Alkandari (2015), Kuwait has adopted the system associated with the Trends in Mathematics and Science Study (TIMSS). Therefore, students in Kuwait study the following mathematical concepts: (1) numerical content for an average of 44 hours; (2) 27 hours on geometric shapes and measures; (3) 17 hours on data display; and (4) 13 hours on other content. Primary schools dedicate 30 hours per week to mathematics, which is 14% of the total instructional time in learning institutions. This is higher than the international average of 23 hours, but lower than the average proportion of instructional time (i.e. 18%). Therefore, although Kuwait gives some priority to mathematics, this prominence is significantly lower compared to other subjects (Alhashem & Alkandari, 2015).

1.3 Focus and Significance of the Study

Ultimately, it is hoped that the current study findings will explain the impact of using two types of visualisation (SCV and PRV) to make mathematical word problems more accessible for students with ADHD. This will enable them to focus more easily when attempting these tasks. It is believed that PRV and SCV can provide solving strategies for students with ADHD, whereby mathematical word problems are translated into visual representations as a means of solving them. Moreover, although the current intervention study was conducted in just one country, it could be argued that the study's findings may help establish strategies and policies in learning institutions, consisting of the use of visualisation with ADHD students in mathematics learning. This could then be duplicated across the country and even throughout the Gulf region, in order to mitigate the mathematical challenges faced by students with learning disabilities, especially ADHD. Furthermore, this study could expand the boundaries of knowledge relating to mathematics problems solving strategies by using visual representations (SCV and PRV) for teaching and learning.

Finally, it is important to emphasise that another focus of this study is to empirically test Papert's theory of constructionism (see Chapter 2) by using visualisation in the form of public artefacts created via SCV. Such a focus is expected to make an important contribution to the field of mathematics education by examining whether students' thinking that is projected outwards (externalisation) can enhance their mathematical performance in primary schools (see section 2.4 and subsections 2.4.1 and 2.4.2), especially amongst students with ADHD.

1.4 Structure of the Thesis

This thesis is organised into eight chapters. The next chapter, Chapter 2, presents a critical review of both seminal and recent empirical literature relating to the theories that underpin mathematics learning and the role of visualisation in mathematical education. It also reviewing the underpinning literature helped investigate how the use of SCV and PRV develops the ability of ADHD students to solve mathematical word problems and the ways that such visualisation strategies impact their behaviour.

Chapter 3 then sets out to explore possible methodological approaches to answering the research questions as well as outlining the underpinning ontological and epistemological assumptions. Additionally, details about the data collection, data analysis methods, sampling (size and criteria) and research ethics are also presented in this chapter.

Chapters 4-7 subsequently present and discuss the findings in response to each of the four research questions, which will be set out clearly at the end of Chapter 2. Finally, Chapter 8 sums up the key findings from each chapter in relation to the research questions and states the limitations of the current study. Additionally, implications for practice are given, as well as the anticipated impact of this research on professional practice, with some suggestions for future research.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter will highlight the perspectives presented in the literature on mathematical learning and the role of visualisation. Additionally, it will shed light on the theories underpinning this study, which helped to develop the research questions. Furthermore, it will provide a definition of ADHD and some of the theoretical perspectives linked with ADHD and executive function. Besides this, it will attempt to clarify these perspectives and the reason for their importance. Finally, a conceptual framework will be set out to summarise all theories that were directly related to the development of this study and its research questions.

2.2 Theoretical Perspectives of Mathematics Learning and Understanding

In order to learn, it is important to think about the kind of learning being produced via a particular learning technique. Skemp (1989), a key authority in the field of mathematics education, describes two models of mathematics learning: habit learning and intelligent learning. The current study will focus on intelligent, rather than habit learning. According to Skemp (1989), habit learning is a type of learning that builds on the ability to memorise information, but not necessarily on the ability to explain it; in habit learning, students rely on knowledge, information and rules delivered by their teachers. For example, when asked for the sum of ‘1+1’, some very young children may be able to answer ‘2’, but be unable to explain why. Skemp (1989) describes this as “rules without reason” (p.2) or instrumental understanding. In contrast, intelligent learning entails the ability to both use and explain a concept (Skemp, 1989). This type of learning leads to what Skemp (1989) refers to as ‘relational understanding’. The current study consequently focuses on intelligent rather than habit learning, as its main objective is to teach students with ADHD how to think and rationally solve mathematical word problems using SCV and PRV, where both types of visual representation provide an explanation of the solutions.

In line with Skemp’s (1989) concepts of instrumental and relational understanding, Kilpatrick, Swafford and Findell (2001) described procedural fluency and conceptual understanding as two of the key components of mathematical proficiency. Meanwhile, Kilpatrick et al. (2001) define procedural fluency as “knowledge of procedures, knowledge of when and how to use them appropriately” (p.121); highlighting the similarity between this concept and Skemp’s (1989) notion of instrumental understanding, in that they both rely on using rules or methods to reach mathematical solutions. Both Skemp (1989) and Kilpatrick et al. (2001) also argued that procedural fluency is crucial for mathematics learners to develop a conceptual understanding, which they defined as the ability to represent mathematical concepts in a range of ways. In the current study, PRV, SCV, and both models of mathematical learning – relational understanding (Skemp, 1989) and conceptual understanding (Kilpatrick et al., 2001) – will be used to develop students’ ability to represent mathematics concepts differently. Representation and representation modes will therefore be discussed in the next section.

2.3 Theoretical Perspectives of Mathematical Representation

2.3.1 Defining Mathematical Representation

Many researchers in the field emphasise the importance of mathematical representation to mathematical learning and understanding (Bruner & Kenney, 1965; Bruner, 1966; Piaget, 1985; Duval, 1999; Kilpatrick et al., 2001; Tall, 2004). For Bruner (1966), representation is viewed as the ability to conceptualise understanding through mental imaging (visualisation), which increases the abilities of manipulation and recall; it involves "the amount of information that must be held in mind and processed to achieve comprehension" (p.45). According to Goldin (1998), mathematical representation is linked to mathematical ideas, together with the following implied structure: "encode[s], evoke[s], produce[s], and stand[s] for, represent[s], or symbolize[s]" (p.144). Moreover, representation refers to the ability to simplify an abstract idea, using characters, images or concrete objects (Bruner, 1966; Goldin, 1998; Jitendra, Nelson, Pulles, Kiss, & Houseworth, 2016). In addition, it "may include manipulative materials (physical objects), pictures or diagrams, real-life situations, spoken language, or written symbols" (Jitendra et al., 2016, p.9). Additionally, mathematical representation can be presented both visually (for example, via images, graphs, diagrams, and drawings) and non-visually, using equations and mathematical models (Purwadi, Sudiarta, & Suparta, 2019). Furthermore, Widada and Herawaty (2017) and Suharto and Widada (2019) define mathematical representation as the main ways or different forms of presenting a mathematical concept.

Representation is the path of communication between diverse elements and topics (Duval, 1999; Goldin, 2008). This has been clarified by Duval (1999), who proposed that representation is "at first necessary for the communication between the subjects" (pp.4-5). In addition, it allows students or others to open a discussion about solving a problem or finding the solution so that they "interact coherently with each other" (Goldin, 2008, p.179). This point supports Papert's theory of constructionism (see section 2.5 Constructionism as an Underpinning Approach to Learning: Papert's Views), where Papert describes how teaching students to think can be developed from opening a conversation with themselves or others, when they create a public artefact. In the case of the current study, this involves creating a drawing (SCV) to solve mathematical word problems. Kaput (1987) and Vergnaud (1987), who asserted that any results that are obtained will be through mathematical representation, also supported the claim that mathematics cannot proceed without representation.

Furthermore, Martin and Schwartz (2005) and Ng and Lee (2009) argue that the role of representation is incorporated into schools through their use of manipulative materials to make mathematical concepts meaningful. Martin and Schwartz (2005) studied the effects of using physical materials on students aged 9-10 years and concluded that physical materials supported students' cognitive ability to solve fraction problems. Similarly, Suharto and Widada (2019) found that using mathematical representation increased the cognitive structure of students' understanding of mathematical concepts, using a sample of 140 high school students in Kota Bengkulu. Further findings for the benefits of using mathematical representation have been presented by Purwadi, Sudiarta and Suparta (2019), who found that by using a concrete material (which they called 'Concrete-Pictorial-Abstract') with 66 third-graders in Padangbulia Village, the students' conceptual mathematical understanding of how to solve fraction problems was developed. Such findings emphasise the influence of using representation in mathematical learning, which can be divided into internal and external representation, as will be discussed in more detail in the following subsections on modes of representation.

2.3.2 Internal and External Representation

Two key types of mathematical representation are highlighted in the literature: internal and external. Internal (or mental) representation is automatic (mental recall; the process happens in the human brain) (Duval, 1999) and relates to mental images (Jitendra et al., 2016). Goldin and Kaput (1996) defined internal representation as the "possible mental configurations of individuals, such as learners or problem solvers" (p.399). Similar views presented by Malafouris (2018) and Barrett (2019), who defined internal representation as a mental process of constructing and manipulating the outside world, which can translate our action toward any experience. According to Malafouris (2018), the internal representation is "called 'cognitivist' view of mind" (p.10), which means that "we are isolated observers of the world, contacting our environments indirectly via the computer interface of our brains." (Barrett, 2019, p.475). This type of representation needs to consider mental functions and the philosophy of the mind (Guttenplan, 2005). Although Jitendra et al. (2016) argue that researchers have focused more on external representation than internal representation, as it is difficult to study mental images, Goldin (2008) points out the continued need for research on internal representation. This should not be neglected, as it is important for cognitive processes to be concerned with mathematics learning and understanding, because representation can enhance mediation between observation and prior experience (Goldin & Kaput, 1996).

In contrast, external (or intentional) representation is more straightforward to investigate than internal representation and is concerned with the "physical action of the represented object on some organic system" (Duval, 1999, p.5). Bussey and Orgill (2019) define external representation as a visual representation, exposed by students by identifying relevant information to construct the new knowledge. External representation is critical in mathematics learning and understanding, as teachers use external representation to help students understand how to explain and analyse their solutions (Goldin & Shteingold, 2001). External representation also aids in developing mental efficiency, which is necessary for internal representation (Orrantia & Múñez, 2013). In a study of 49 secondary school students, Múñez, Orrantia and Rosales (2013) found that an external representation (graphs) is effective for problem-solving, as it enhances mental representation in explaining the solution. Arguably, this result indicates that internal and external representation are linked to each other. Thus, the current study will focus on external representations, using manipulative materials (for example, PRV and SCV) to enhance children's representation of mental images.

2.3.3 Modes of Representation

In addition to different types of mathematical representation (internal and external), the literature has also examined multiple modes of representation. Bruner (1966), a key scholar on modes of representation, proposed three modes: the enactive or concrete mode (response or activation), iconic representation (using visual or sensory aids), and the symbolic mode (level of the concrete and/or iconic translation of experience).

In the context of mathematics, Tall (2004) refers to three worlds, which are similar to Bruner's three modes. The first is the embodied world of mathematics, in which the focus is on the use of sensory experience (iconic mode), such as visualisation. Second, Tall (2004) uses the phrases, 'worlds of mathematics' and the 'perceptual world' to denote the enactive mode defined by Bruner (1966). The third world is the formal world or axioms, which refer to the ability to resolve the symbolic form, using previous experiences. Similarly, Piaget (1985) described

Bruner's (1966) first two modes as empirical (enactive) and pseudo-empirical abstraction (iconic) and proposed reflective abstraction as the third level of manipulation and understanding, akin to Bruner's symbolic mode. Meanwhile, Lesh, Landau and Hamilton (1983) defined five distinct mathematical representations comparable to Bruner's modes: real-world situation and manipulative models, similar to Bruner's concrete mode; pictures, which are similar to Bruner's iconic mode; and, finally, spoken and written symbols, which are similar to Bruner's symbolic mode.

However, according to Bruner's (1966) three modes of representation, "it may be possible to by-pass the first two stages. But one does so with risk that the learner may not possess the imagery to fall back on when his symbolic transformation fails to achieve a goal in problem solving" (p.49). This is why the current study examines the effects of two different methods of using visualisations (PRV and SCV), in order to understand which method can provide a better translation of the mathematics problem and allow it to be solved through symbolic forms. Thus, the role of visualisation in mathematics education will be discussed in more detail in the next section.

2.4 Role of Visualisation in Mathematics Education

The theory underpinning the current study is based on Bruner's (1966) iconic mode, which involves using visual aids to enhance mental ability, as discussed in the previous sections. The main argument in the literature is that visualisation can help improve mathematical understanding by enhancing cognitive ability through the development of mental images (Bruner, 1966; Skemp, 1989; Hershkowitz, Arcavi, & Bruckheimer, 2001; Kilpatrick et al., 2001; Arcavi, 2003; Jonassen, 2003; Tall, 2004; Giaquinto, 2011). This is clearly relevant to the use of PRV and SCV and the rationale for choosing Bruner's (1966) iconic mode of representation over other modes. Visualisation may be defined as the mental process of using images to enhance thinking and develop cognitive ability (Jonassen, 2003; Giaquinto, 2011). Sorva, Karavirta and Malmi (2013) state that visualisation refers to an internal conceptual model, which can provide clarification and allow for the construction of knowledge using images (for example, drawing on paper or blackboards, and using software). Arcavi (2003) identified visualisations as object processes (for example, number lines), in which the meaning can be constructed by individual learners. The above definitions resonate with Bruner's (1966) iconic representation, which depends on visual sensory representations to build a conceptual understanding of how to solve problems in symbolic form (see subsection 2.2 and 2.4). Duval (1999) linked the use of these representational tools to representational ability, which is a notion also supported by Bruner (1966) and Bruner and Kenney (1965) in empirical studies, aimed at demonstrating the effectiveness of visualisation.

Empirical studies have tested the effectiveness of various visual aids, including pictures, diagrams, drawings and visual software (Hershkowitz, Ben-Chaim, Hoyles, Lappan, Mitchelmore, & Vinner, 1989; Zimmermann & Cunningham, 1991; Hershkowitz et al., 2001; Arcavi, 2003). For example, a study by Garderen, Scheuermann, and Poch (2014) found that training students with learning disabilities to use visual strategies (diagrams) can improve their ability to solve word problems by mapping the relationships and identifying important quantities of the problem. Furthermore, Arcavi (2003) mentioned that "visualisation can be even more than that: it can be the analytical process itself which concludes with a general formal solution" (p.70). This suggests that the use of visualisation, such as diagrams, can help students analyse the process of reaching a solution. More specifically, a study by Pantziara, Gagatsis and Elia (2009) on 198 sixth-grade students in Cyprus found that different types of diagram (network, hierarchy and matrix) had varying effects on students' performance, depending on their ability to use diagrams for problem-solving. Uesaka, Manalo and Ichikawa (2007) reported similar results after comparing 323 New Zealand students and 291 Japanese secondary school students, aged 13-15 years. The former, who used self-constructed diagrams, were more successful at solving algebra problems. More recently, in relation to ADHD, Alqahtani, McGuire, Chakraborty and Feng (2019) tried to test how using visual representation to present different types of information, such as textual, tabular and graphical data, could help a sample of 12 participants with ADHD, comprising university students aged 18-24 years. The above study, using controlled experiments, found that students with ADHD showed better interaction with the information (textual, tabular and graphical) than they did before the experiment was conducted.

Similarly, administering the System Usability Scale questionnaire to 98 university students in northern Taiwan, Tsai and Yen (2013) reported positive effects on the respondents' learning and motivation, due to the usability of a visualisation program for two- and three-dimensional objects. Similarly, Yıldız, Güven and Koparan (2010) found an improved understanding of geometry among 25 eighth-grade students in Turkey, who used Cabri 2D software on drawings of height and a perpendicular bisector. A Cypriot study on eight sixth-grade students conducted by Elia and Philippou (2004) likewise indicated that the use of decorative images as a translator for problem-solving helped students give correct answers; however, the small sample size limited the generalisability of their findings for the effect of a picture task on students' mental ability. Teahen (2015) found that 10 students in Years 4 and 5 in New Zealand, displaying low achievement in mathematics, benefited from using drawings to visualise mathematical word problems, but the generalisability of this result was limited by the small sample size. However, similar results from a much larger sample size for mathematical word problems, using a similar drawing strategy as in the previous study, were obtained by Csíkos, Szitányi and Kelemen (2011) in a study of 244 third-grade students in Hungary.

The studies discussed thus far demonstrate the benefits of using visualisation in mathematics learning. Thus, several studies are being conducted on the use of PRV and SCV as learning methods to determine their effectiveness in improving the ability of students with ADHD to solve mathematical word problems, where it could be highlighted that the use of PRV and SCV reflects external representation through visualisation. Both SCV and PRV will be discussed in more detail in the following subsections.

2.4.1 Self-Constructed Visualisation (SCV)

SCV refers to visualisation constructed by the learners themselves, as opposed to being given to them. An example of self-constructed visualisation is creating a drawing. In the current study, SCV will be achieved using a drawing strategy, as exemplified by Figure 2.1. The term SCV was developed by the current researcher from Papert's (1993) constructionist learning theory by creating a public artefact, which holds the view that knowledge can be constructed through self-creation. In general, a drawing can help produce an illustrative representation of a concept described in a text (Van Meter, Aleksic, Schwartz, & Garner, 2006). Moreover, drawing can be defined as the learner's ability to construct a picture as an external visual representation, so as to make the content easy to grasp (Carney & Levin, 2002; Van Meter et al., 2006; Teahen, 2015). In addition, drawing may be considered as a strategic process, because it aims to improve the organisation of knowledge, which can in turn enhance problem-solving ability (Van Meter et al., 2006). Furthermore, to give more understanding of the conflict between drawing and figures, Yaoukap, Ngansop, Tieudjo and Pedemonte (2019) define drawing as a way of establishing figures: “drawing is the material representation of the figure on a representation medium (table, computer screen, etc.)” (pp.75-76). Besides, a drawing strategy can be useful in many areas, one of which is learning disability (Wang, Yang, Tasi, & Chan, 2013).

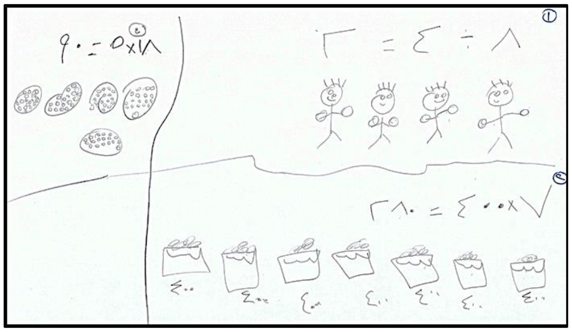


Figure 2.1 An example of SCV

Generating a drawing has a variety of benefits (Rellensmann, Schukajlow, & Leopold, 2017; Yaoukap et al., 2019). First, it can enhance awareness of the objects involved in a task and their relationships (Van Meter & Garner, 2005). Second, it can encourage focus on the information in the task (Van Meter & Garner, 2005; Rellensmann et al., 2017). Finally, drawing can provide a description of the problem to enhance the likelihood of finding a solution (Rellensmann et al., 2017). However, Leutner, Leopold and Sumfleth (2009) highlight the cognitive load that is added by generating a drawing, which can affect outcomes; thus, the act of constructing a drawing should not be too demanding. Additionally, Yaoukap et al. (2019) argue that students could have some difficulty in articulating the drawing or understanding the figures represented by the drawing. Therefore, the drawing should be as clear as possible to indicate the figure being created. This point is made in empirical studies, which have tried to emphasise the influence of instruction on generating a drawing and its impact on mathematical problem-solving (Hembree, 1992; Van Meter et al., 2006).

However, Van Meter et al. (2006) explained that the use of drawing does not show significant results in mathematics performance, but students who receive instruction in generating drawings demonstrate better results. This may indicate that when students attempt to use SCV, the method may not be effective without instruction on how to create or construct their drawing. Van Meter et al. (2006) used an experimental design to study 69 fourth-grade and 66 sixth-grade students in the Midwest of the USA. They found that although student-generated drawings (constructed drawings) generally had no significant impact on students' problem-solving abilities, the students who received instruction when drawing did show some improvement. This result is also supported by De Bock, Verschaffel, Janssens, Van Dooren and Claes (2003), whose investigation into the delivery of instruction on producing drawings yielded an insignificant result, especially in terms of mathematical performance.

In addition to the use of instruction in the construction of drawings, other factors can affect students' ability. One such factor is the quality of the drawing, which refers to the degree of accuracy with which objects and their relationships are depicted in the drawing (Van Meter & Garner, 2005; Uesaka, Manalo, & Ichikawa, 2010). According to Rellensmann et al. (2017) and Teahen (2015), the quality of a drawing will depend on numerous aspects, such as the age of the students, their understanding of the content, and their drawing style. Van Meter et al.'s (2006) study of 135 students in grades four and six found that drawing was more beneficial for sixth-grade students than for fourth-grade students. Similarly, van Essen and Hamaker (1990) highlighted that first- and second-grade students did not show any improvement in problem-solving when using drawing, unlike fifth-grade students, who did show some improvement.

Regarding the element of understanding content, Schwamborn, Mayer, Hubertina, Leopold and Leutner (2010) studied 196 ninth-grade students in Germany and concluded that the accuracy of their drawing increased with a better understanding of the content. Empirical evidence underscores the effects of the drawing style used; for example, schematic drawing was found to be a more successful tool than pictorial presentation in a study of 214 fourth- and fifth-grade students in the USA (Edens & Potter, 2010), and in another study of 33 sixth-grade students in Ireland (Hegarty & Kozhevnikov, 1999). Additionally, Yaoukap et al.'s (2019) study highlighted that the use of drawing to solve geometry problems amongst 30 14-16 year olds was effective for modifying their understanding of solving geometry problems and building their arguments for comparing the figures with what they had drawn. In addition, empirical studies provide some evidence of drawing being able to improve the working memory via visual sensory parts of the brain. A study by Meade (2019) on 210 undergraduate students who were studying words showed that the use of drawing to express some words had a better influence on the memory than writing, whereupon drawing enabled better recognition amongst the participants.

However, a research gap exists in the use of drawing for teaching, especially among students with ADHD, for whom a major challenge appears to be the inability to use their working memory to respond to or recall information (Clark et al., 2007; Young, Morris, Toone, & Tyson, 2007). Although drawing can arguably improve working memory, and many researchers have addressed the benefits of using visualisation amongst students with ADHD (Clark et al., 2007; Egeland, 2007; Kercood & Grskovic, 2010; Lineweaver et al., 2012), other researchers have focused specifically on the use of drawing in mathematics teaching for these students. Self-generated drawing can have positive effects on mathematics learning for students with ADHD. For example, drawing allows students to use their motor skills, which can improve their mathematical performance (Kercood, Grskovic, Lee, & Emmert, 2007). As discussed in previous sections, drawing is important in external representation and can help integrate different types of representation and cognitive processes, using graphs, matrices and pictures (Van Meter & Garner, 2005). Despite its benefits, the literature has addressed the limitations of using drawing in teaching in general (Van Meter & Garner, 2005).

2.4.2 Passively Received Visualisation (PRV)

The key point of PRV is that the visualisation is given and not created or constructed. In the current study, PRV refers to the visual object by using images for the mathematical situation, in order to solve mathematical word problems. One good example of PRV is the use of images or objects to present a problem; in this way, visualisation is passively received via visual images, as shown in Figure 2.2. This is how the current research developed the term, PRV. Using images (i.e. PRV) may be considered as a means of teaching or learning through visualisation, which helps make unfamiliar material more familiar for students (Taber, 2018). In addition, images can make complex conceptual or abstract knowledge available to students by providing a clear picture of the concepts and removing the confusion (Csíkos et al., 2011; Taber, 2018; Dongwi & Schäfer, 2019). According to Tall and Vinner (1981) and Hegarty and Kozhevnikov (1999), visual images may be defined as a mental representation of the manipulative objective in the mind.

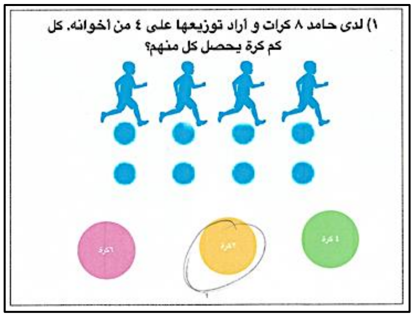


Figure 2.2 An example of PRV

Many researchers affirm that visual images can positively influence mathematics learning and change students' attitudes towards mathematics concepts (Arcavi, 2003; Bjuland, 2007; Gal & Linchevski, 2010). These researchers have found that the use of visual images in teaching and learning environments can complement the teaching of any mathematical concept and enhance higher thinking in problem-solving. As the ability to solve problems requires being able to comprehend the relevant textual information (Jonassen, 2003), the use of PRV enables the student to visualise the information in a mathematical word problem.

Distinguishing between different types of image or visualisation is important, because images can work differently, depending on the reason for using the images (Csíkos et al., 2011). Presmeg (1986) identified five categories of image: (1) concrete pictorial imagery, referring to an actual situation formulated in a person's mind; (2) pattern imagery is where relationships are represented visually through using physical (i.e. symbolic) and non-physical (i.e. iconic) senses to paint pictures in the mind; (3) memory imagery, referring to the recall of an existing image in the memory; (4) kinaesthetic imagery, referring to the images that someone can feel and touch; and (5) dynamic imagery, where images are created to solve problems. Meanwhile, Kozhevnikov, Hegarty, and Mayer (2002) categorised images into two groups: spatial imagery, or the ability to represent the relationship between different objects, and visual imagery, which is the ability to represent an object. There are some differences and similarities between Presmeg's (1986) and Kozhevnikov et al.'s (2002) image types. Both have roots linked to Bruner's (1966) three modes of representation, whereby it seems that PRV represents Presmeg's (1986) pattern and dynamic imagery, while Kozhevnikov et al.'s (2002) spatial imagery is more relevant to PRV.

However, some scholars refute the benefits of using images to learn mathematics, such as Tversky (2010), who argued that images (diagrams) can cause confusion for the learner, who may be unable to conceptualise the meaning of the image, and the use of sketches can be more vague than diagrams. In addition, Gates (2018) clarifies that it is not always easy to work out what images are supposed to represent. Thus, the clarity of the images is critical, or they will be useless. Furthermore, some researchers, such as Ozdamli and Ozdal (2018), have found that teachers do not want to use visual representations of information, because it is time-consuming and adds to their workload. Moreover, Widodo and Ikhwanudin (2018) revealed that students did not find visual media to be a beneficial tool for learning mathematics and as a result, did not improve their ability to solve mathematics problems.

Nevertheless, other scholars have found the use of images to have a beneficial impact on learning mathematics. For example, Dongwi and Schäfer's (2019) qualitative case study, involving 17 students in grade 11, tested the use of visual images to solve geometry word problem tasks. They consequently found that the use of visual images was linked to the reasoning ability to solve geometry word problems. Although the above results are an important contribution to the literature on the use of visual images to enhance mathematics learning, the sample size was too small to be able to generalise this result. In addition, the process of using a mental image to solve geometry word problem tasks was unclear. Hence, the question arises of whether using a qualitative case study, as in Dongwi and Schäfer's (2019) study, was enough to develop a clear view of the impact of using visual images in mathematics learning.

Notwithstanding the above, Bernard and Chotimah (2018) used PowerPoint images to make mathematics more meaningful by adopting an open-ended approach (the students could provide multiple answers for a single problem) in one elementary classroom. The above experiment emphasised that the use of visual images improved students' reasoning ability to apply numerical theories. Although their study provided evidence of the importance of using visual images, other testing methods, such as surveys or interviews, could strengthen their argument. Despite the advantages and disadvantages of using images in teaching and learning mathematics, the current study asserts that using PRV, consisting of visual images, with ADHD students can help them solve division and multiplication word problems.

2.5 Constructionism as an Underpinning Approach to Learning: Papert's Views

Educational theories offer an opportunity to improve educational outcomes by providing new interpretations of learning, which enable a better appreciation of how students learn and therefore, how they can best be supported. However, there are numerous conflicting views of the effectiveness of different teaching methods and techniques. Hence, in order to decide which style of learning to encourage, educators should first consider what kind of teaching methods they need to employ to achieve the desired learning outcomes (Lampert, 1990). In this study, mathematical learning is approached through what could be characterised as a "constructionism as interpreted by Papert" perspective.

Piaget (1985) and Papert (1993) generally agree that knowledge is constructed and both their theories show how people learn and make sense of the world through their learning experience, but their understanding of how meaning is constructed differs. For example, Papert (1993) used the externalisation of thinking to express how learning is constructed, whereas Piaget (1985) focused on activity-based learning. Additionally, Piaget's theory mainly relates to the way that children develop their thinking over time, where Papert's theory is aimed at understanding how people can use art for learning (by making things; public artefacts), in order to open up a dialogue with themselves or others to construct new knowledge (Ackermann, 2001; Reynolds, 2010). Exploring this difference enables us to approach mathematical learning in a new way (Fosnot, 2013; Halpenny & Pettersen, 2014). Constructionism places less emphasis than constructivism on activity-based learning, but it does promote the idea that knowledge is largely self-created (Ackermann, 2001), and this is what Papert (2005) referred to as 'Teaching Children Thinking', or their ability to process the complexity of the information, thereby improving their understanding and thinking ability. In the context of the current study, Papert's view of teaching children how to think can be achieved using SCV, which can help students with ADHD understand how to solve mathematical word problems, compared with the use of PRV. This is where SCV can be used to understand how students with ADHD can manipulate the information in word problems through a visual representation to solve mathematical word problems (see section 2.3 Theoretical Perspectives on Mathematical Representation; subsection 2.3.1 Defining Mathematical Representation, and section 2.4 Role of Visualisation in Mathematics Education).

Papert (1993) therefore formulated constructionist theory, a subset of the constructivist view. According to Papert's (1993) theory of constructionism, students learn best by projecting what they know by creating a public artefact. Externalisation refers to what people have in mind on any topic, externalising what they already know from previous experience. The externalisation process occurs through relational thinking, whereby knowledge and skills are superimposed on past experiences and existing knowledge. This is why learning is considered to be progressive (Raskin, 2008). In the context of this current study, externalisation refers to students externalising what they know and understanding how to solve word problems (for example, division: 6÷3, which means 6 divided by 3), so that they project what they already know. However, this understanding may be correct or erroneous. The effectiveness of constructionism in learning will depend on the students' ability to externalise mental models, reflect upon the knowledge represented by the models, and apply the knowledge, either during the testing or learning process, to prove proficiency or display competence in practical scenarios (Raskin, 2008). Once these students project what they already know about division from other people (for example, teachers, parents and peers), using the materials around them, Papert (1993) refers to a process of "public artefacts": public means that everyone can see them, and the artefacts represent knowledge. For example, Papert (1993) refers to knowledge as anything from knowing how to build a sandcastle to information about the universe. In the present study, the drawings that are created constitute public artefacts.

The current study will test the claim in Papert's (1993) theory that people learn best by externalising their understanding of a topic through the creation of a public artefact. The relevance and suitability of the models are theorised to reinforce constructionism during learning and can facilitate learning and reinforce knowledge and skills (Jones & Araje, 2002). There are two groups in this current study: the intervention group, used to test Papert's (1993) theory of constructionism (i.e. SCV), and the comparison group (i.e. PRV), which will not be engaging in active construction. The current study will use public artefact constructionist theory, because this can provide an understanding of how thinking or understanding in relation to mathematical topics can be projected by creating public artefacts. In this study, visualisation will be used to solve word problems by constructing or creating drawings. The relevance of the artefact will determine students' ability to externalise thinking by creating and constructing drawings. This study aims to demonstrate that students can learn more effectively when they construct public artefacts through SCV than when they engage in PRV to solve a mathematical word problem.

2.6 Issues with Mathematical Word Problems

Mathematics is considered as the basis of our lives and how we understand the world around us (Metikasari, Mardiyana, & Triyanto, 2019). According to Metikasari et al. (2019) mathematics is important, because it is involved in technology development, logic and quantitative calculation, and creativity through critical thinking. Therefore, in mathematics, a higher level of thinking is required to solve mathematical problems. Mathematical word problems can be considered a difficult task that students deal with in their mathematics learning because they reflect many factors in mathematics learning (Csíkos et al., 2011). Thus, word problems are different from other mathematical tasks because the word problems are set through text to describe the mathematical situation (Pongsakdi et al., 2019). According to Lave (1992) and Csíkos et al. (2011), word problems can reflect mathematical structures, situations, actions, analyses, and reasoning. Thus, multiple thinking processes occur when solving mathematical word problems. As the ability to solve mathematics word problems is central to school mathematics achievement (English & Halford, 1995), the current study seeks to provide help for ADHD students, using visual representations through SCV and PRV to develop a procedure to solve mathematical word problems.

Language skills are highly important in mathematics learning (Xin, Jitendra, & Deatline-Buchman, 2005; Ernest, 2011; Alt et al., 2014). According to Trakulphadetkrai et al. (2017), mathematical difficulties in word problems can be linked with limited reading comprehension and vocabulary abilities; they can also stem from “a lexically ambiguous term” (p.1). For example, mathematics learners mix academic and everyday vocabularies, which sound similar but have different meanings in the context (Trakulphadetkrai et al., 2017). Understanding why students tend to struggle with mathematical word problems requires comprehending the role of the cognitive system in mathematical and mathematical thought processes (Duval, 2006). However, to understand cognitive issues in mathematics, it is first necessary to address students' difficulties in this area. Ernest (2011) also supported the notion that language can play a critical role when solving mathematical word problems. Thus, both cognitive issues and the role of words in solving problems are important aspects of mathematics, which will be addressed in this current study.

The need to plan, identify keywords, and follow instructions can pose major challenges to solving word and written mathematics problems (Xin et al., 2005; Prediger, Erath, & Opitz, 2019), especially for students with learning disabilities (LD) and ADHD, as these students may struggle with language (Shalev & Gross-Tsur, 2001; Czamara et al., 2013; Price & Ansari, 2013; Prediger, Erath, & Opitz, 2019). Many researchers have reported that most students with LD and other special needs encounter difficulties in mathematics, especially with words or written problems (Cawley & Miller, 1989; Parmar, Frazita & Cawley, 1996). Students with LD often exhibit low levels of language use and reading skills (Ernest, 2011), and students with ADHD are similarly described in both the *International Classification of Diseases*, 10th Revision (ICD-10) and the *Diagnostic and Statistical Manual of Mental Disorders*, Fifth Edition (DSM–5). ADHD has been clearly related to impaired executive functions and a deficit in working memory, which affects language abilities and mathematical outcomes, especially when dealing with word problems (Barkley, 1997; Rapport, Orban, Kofler, & Friedman, 2013; Alloway & Cockcroft, 2014; see subsection 2.7.1 for further discussion on this). Executive functioning is low in students with ADHD, which can cause them to experience difficulties with behaviour inhibition, making them impulsive (Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005; Etnier & Chang, 2009). As discussed in section 2.4, the use of visual aids (for example, PRV and SCV) can be a key solution for helping students with ADHD resolve mathematical word problems, by enhancing their ability to present these problems as mental images.

2.7 ADHD: The Theoretical Perspectives

The complexity of ADHD has generated disagreements over both its definition and measures (Barkley, 2006), and the various theoretical perspectives presented in the literature. Using the lens of ADHD theories, this section will examine definitions provided by psychology experts, based on the international perspective of ADHD. Here, the main characteristics of ADHD diagnosis will be highlighted (inattention, impulsivity, and hyperactivity), combined with the basis of and reasons for the definitions. International and theoretical perspectives of ADHD diagnosis and its implications are discussed below.

There are three key international classifications for identifying and diagnosing ADHD: the ICD-10 (World Health Organization, 1993), the DSM-5 (American Psychiatric Publishing, 2013), and the International Classification of Functioning Disability and Health (ICF) (World Health Organization, 2001). These three classifications highlight three core ADHD symptoms: inattention, or the inability to be organised, pay attention and stick to tasks; impulsivity, or the inability to be patient, wait and stay in one place, and hyperactivity, or being overly active. These ADHD classifications are built on theoretical foundations that are important for understanding various societies' understanding of and rationale for ADHD diagnoses. According to DSM-5, the three core symptoms can be present before the age of 12, and the symptoms should be evident in more than one setting (for example, home and school), as the diagnosis will depend on observations of people in these settings. In the DSM-5 and ICD-10, inattention, impulsivity and hyperactivity are divided into a number of symptoms, with at least six being present over a period of at least six months.

A self-description questionnaire, the Strengths and Difficulties Questionnaire (SDQ), can be used to diagnose ADHD. The SDQ will enable a brief assessment of a child for the most important psychopathological features, such as emotional symptoms, peer problems, behaviour, and ADHD (Klasen et al., 2000; Muris, Meesters, & van den Berg, 2003; Arman, Amel, & Maracy, 2013). It can examine and analyse factors from teachers, parents and children aged 4-16 years, within five minutes (Klasen et al., 2000; Muris et al., 2003; Arman et al., 2013; Algorta, Dodd, Stringaris, & Youngstrom, 2016). The SDQ contains 25 items. Teachers and parents receive the same version of the questionnaire, which is similar to the children's version, with an "equal number of items on each relevant dimension" (Arman et al., 2013, p.501). The SDQ questionnaire has been used by the participating schools in this study for diagnosing ADHD.

Both the ICD10 and the DSM-5 are based on a biological theory that classifies ADHD under neurodevelopmental disorders, which are treated clinically. This biological theory holds that the heritability of ADHD is an individual factor, reflecting individual differences, even though the environment also has critical influences (Thapar, Cooper, Eyre, & Langley, 2012; Li, Chang, Zhang, Gao, & Wang, 2014). In addition, based on the findings from brain scans, Willcut et al. (2005) and Armstrong (2010) associated ADHD with executive functioning in the frontal area of the brain. However, following Brown (2006), questions may be raised about the accuracy of brain scans and the extent to which ADHD may be linked with executive functioning. Executive functioning is considered to determine neuropsychological functions (self-control, attention, planning, reasoning and working memory skills) and have a direct effect on human behaviour (Pennington & Ozonoff, 1996; Welsh & Pennington, 1988; Biederman et al., 2004; Crone, 2009).

Furthermore, hormones, specifically dopamine, can result in the diverse underpinning of executive processes, thereby influencing ADHD behaviour (Sagvolden, Johansen, Aase, & Russell, 2005).

The ICF, in contrast, is not built on a solely biological basis, but also on bio-psychosocial theory (BPS), which views the limited functions and activities associated with ADHD from three perspectives: biological (heredity, hormones and the brain), psychological (cognitive), and social (participation, interaction and relationships) (Barkley, Murphy & Kwasnik, 1996; Barkley, 1997; British Psychological Society, 2000; Cooper, 2008). The leading scholar on BPS is Engel (Gliedt et al., 2017), who challenged the biomedical model and in 1977, proposed a new medical model that intertwined three factors: biological, psychological and sociological (Engel, 1977; Gliedt, Schneider, Evans, King, & Eubanks, 2017). In addition, according to Engel (1977), using BPS means that any element of human function can influence other elements, leading to the understanding that all human illnesses can be connected to biological, psychological and social factors (Green & Johnson, 2013; Gliedt et al., 2017).

This theory extends beyond brain functions and inherited or genetic aspects to explore the effects of other sources, such as the environment, context, and the individual (Hoza, 2007; Salamanca, 2014). Salamanca (2014) highlighted bio-psychosocial interaction with the environment (home or school), background and personality in ADHD diagnoses. This theory can be considered as the most comprehensive, as it includes all perspectives from the earlier theory (biological) and describes the mechanism of human functions (activities, bodily functions and social interactions; Salamanca, 2014). Researchers such as Timimi and Taylor (2003), Rafalovich (2004) and Timimi (2010) claimed that ADHD arises from sociological and genealogical factors and that children's behaviour reflects their cultural, political, and social contexts. However, this view can arguably be considered as part of bio-psychosocial theory, rather than as a separate theory, because bio-psychosocial theory is a combination of two elements: social and biological (as mentioned earlier).

In conclusion, international definitions and classifications of ADHD are highly important for helping ADHD researchers understand how ADHD can be identified from different perspectives. The international perspectives (i.e. ICD-10, DSM-5, ICF) are built on two basic theories: biological (ICD-10 and DSM-5) and bio-psychosocial (ICF). Although bio-psychosocial theory may be seen as broader, the current study will adopt biological theory, as it is used in ADHD diagnosis in Kuwait: the context of this current study.

2.8 Executive Function

Executive function (EF) refers to neurocognitive processes that take place in working memory, in relation to the current situation and to identify possible choices, so that the best decision can be made (Willcutt et al., 2005). A similar definition is provided by Etnier and Chang (2009), who viewed EF as “a higher order cognitive ability that controls basic, underlying cognitive functions for purposeful, goal-directed behaviour and that has been associated with frontal lobe activity” (p.470). Additionally, Silverstein, Faraone, Leon, Biederman, Spencer and Adler (2020) define EF deficit as a lack of self-control, poor self-regulation, and an inability to plan multiple tasks, whereby they underline EF deficits as “deficiencies of higher order cognitive processes” (p.41), calling it “executive dysfunction” (p.41). Nevertheless, it may be noted that EF is not one of the core components of ADHD diagnosis manuals, mentioned in section 2.7 and subsection 2.7.1, with some researchers suggesting that it is not central to ADHD (Silverstein et al., 2020). Arguably, impulsivity can reflect the EF deficit (for information about impulsivity, see section 2.7.1), where

Willcutt et al. (2005) state that children with ADHD show weakness in EF, which affects their working memory and consequently inhibits their response control, while increasing impulsivity.

Moreover, EF deals with action in response to a particular situation; this action can be automatic or controlled, as it involves planning, correcting errors, making decisions, and implementing actions (Hughes & Graham, 2002). According to Barkley (1997), four executive neuropsychological functions are linked to ADHD inhibition behaviour (inability to socialise): working memory, self-regulation, internalisation of speech, and reconstitution. Arguably, these four executive neuropsychological functions could be the reason why students with ADHD show low academic achievement and school performance, anxiety, aggression, desperation, and poor peer and family relationships (Barkley, 1997; Rapport et al., 2013; Alloway & Cockcroft, 2014).

Working memory is an important aspect of this research. According to Rapport et al. (2013), 68% of 25 cognitive studies highlight working memory as the "primary target for remediation" (p.1239). Working memory is defined as a temporary system with low capacity storage (Rapport et al., 2013). In ADHD, working memory can affect the external and internal representation of information, which is temporally controlled (Barkley, 1997). Working memory in ADHD can affect the ADHD sufferer's ability to maintain order in the sequence of events over a long period of time, which can affect their ability to recall and hold information in the mind (Barkley, 1997; Kofler, Alderson, Raiker, Bolden, Sarver, & Rapport, 2014). Furthermore, the ADHD sufferer is anticipatory in planning and faces a deficit in time organisation (Barkley, 1997; Kofler et al., 2014). Gathercole, Alloway, Willis and Adams (2006), and Alloway and Cockcroft (2014) linked the deficit in working memory to reading achievement. Alloway and Cockcroft (2014) added that it can be also linked to mathematical performance, observing that "low working memory scores are closely related to poor performance on arithmetic word problems" (p.287).

Using the existing literature, this current study will explore whether it is possible to control EF in sufferers of ADHD by providing learning methods (i.e. SCV and PRV) to help them change their behaviour (for example, their impulsivity, hyperactivity or inattention). Furthermore, by using SCV and PRV, this study aims to enhance the development of representation and build a mental image to improve the ability of students with ADHD to solve mathematical word problems.

2.9 Teachers' and Students' Perceptions

It is important to understand teachers' and students' thoughts and views of using SCV and PRV, in order to build a comprehensive understanding of the impact of using them on developing the ability of students with ADHD to solve mathematical word problems and on their accompanying behaviour. Thoughts and views on a topic, activity, being, etc. are also called perceptions (Hidayah Liew Abdullah, Hamid, Shafii, Ta Wee, & Ahmad, 2018). The general understanding of a perception is a reflection of an individual's view through experiences and communication with the environment and the surrounding people, which can help evaluate that experience (Struyven, Dochy, & Janssens, 2010; Hidayah Liew Abdullah et al., 2018).

Scholars have defined the concept of perception in different ways, but their definitions resonate with reflections on experiences. For example, Atkinson (2013) defined perception as understanding information transferred from the surrounding environment, while Cardwell (2010) highlighted that perceptions combine the brain's processes for understanding what makes sense from the perceived input via the sensory system. Other scholars, such as Wu, Pease and Maker (2019), have clarified that perceptions are about giving participants the opportunity to have their voices heard. The current study is interested in all of these definitions, because the objective of collecting teachers' and students' perceptions is to give them the chance to be heard, and to share their experiences, in order to understand how SCV and PRV make sense to them.

The literature also explains the importance of reviewing the definition of attitudes and beliefs to understand how these two terms diverge from perceptions. However, there is no single definition of attitude, and different researchers define it in different ways, depending on how they measure it (Di Martino & Zan, 2009). The literature linked with psychological behaviour shows how people behave or react to an experience. Attitude has psychological roots related to Jung (1964), who used the term attitude to explain the willingness to respond to a situation. Meanwhile, Eagly and Chaiken (1993) defined attitude as "a psychological tendency that is expressed by evaluating a particular entity with some degree of favour or disfavour" (p.1). Similarly, Di Martino and Zan (2009) referred to attitude as a student's choice of situations and how they behave toward their choice. Arguably, attitude is therefore a term that describes the emotions related to an experience or situation. However, although the current study explores students' and teachers' opinions and views of using SCV and PRV, the way that they behave while using SCV and PRV is beyond the scope of this study, which is not concerned with whether the participants like or dislike using SCV or PRV.

Regarding beliefs, Besnard and Hollnagel (2014) defined them as an idea or story built on people's assumptions, which could either be true or false. Pouillon (2016) highlighted that to believe is to "state a conviction" (p.485). From these definitions, it may be concluded that beliefs signify faith that something will work. As the current study participants had not solved word problems before, it was not possible to test their beliefs about using SCV or PRV prior to the study. Thus, perceptions give a clearer overview of the impact of using SCV and PRV on the ability of students with ADHD to solve mathematical word problems and their consequent behaviour.

2.10 Conceptual Framework

Drawing from the relevant literature presented earlier in this chapter, Figure 2.2 sums up the study's underpinning theories and their relationship to each other, as well as in relation to the research focus on the potential effect of SCV (and PRV) on students' mathematical word problem-solving ability and ADHD behaviour.

In relation to the research focus on the potential effect of SCV and PRV on students' word problem-solving ability, the study draws from Papert's (1993) theory of constructionism, which discusses the possibility of developing students' learning abilities through a process of externalisation by creating a public artefact (see section 2.5). This idea is related to the concept of external representation (Duval, 1999; Goldin & Shteingold, 2001; Orrantia & Múñez, 2012), particularly the enactive and iconic modes of representation (Bruner, 1966; see subsection 2.3.3). More specifically, the current study adopts the iconic mode of representation, which could help achieve the symbolic mode, as Bruner (1966) argued that

> it may be possible to by-pass the first two stages [enactive and iconic]. But one does so with risk that the learner may not possess the imagery to fall back on when his symbolic transformation fails to achieve a goal in problem solving. (p.49)

The current study argues that these views of Papert and Bruner could help develop intelligent learning rather than habit learning (Skemp, 1989; see section 2.2), and conceptual understanding rather than procedure fluency (Kilpatrick et al., 2001; see section 2.2).

In relation to the research focus on the potential effect of SCV and PRV on managing the behaviour of students with ADHD, the ADHD concept is linked with two related factors: the brain and behaviour. Regarding the former, EF is the main factor affecting both working memory (ability to plan) and cognition (problem solving) (Hughes & Graham, 2002; Willcutt et al., 2005). Regarding the latter, ADHD behaviour can be conceptualised in three categories: impulsivity, hyperactivity and inattention, with the last two categories being traditionally presented together as per the *Diagnostic and Statistical Manual of Mental Disorders* (see section 2.7). EF is thought to influence all three behaviour categories (Barkley, 1997; Willcutt et al., 2005; Etnier & Chang, 2009).

Although the current study fully acknowledges that the brain is closely linked to behaviour, as shown in Figure 2.2, the study does not focus on the former (hence, the ‘brain’ section of Figure 2.2 is greyed out). Instead, it focuses on collecting data related to the behaviour of students with ADHD. Specifically, the study sets out to explore whether using SCV to solve mathematical word problems could help manage ADHD behaviour (impulsivity, hyperactivity and inattention), compared to using PRV.

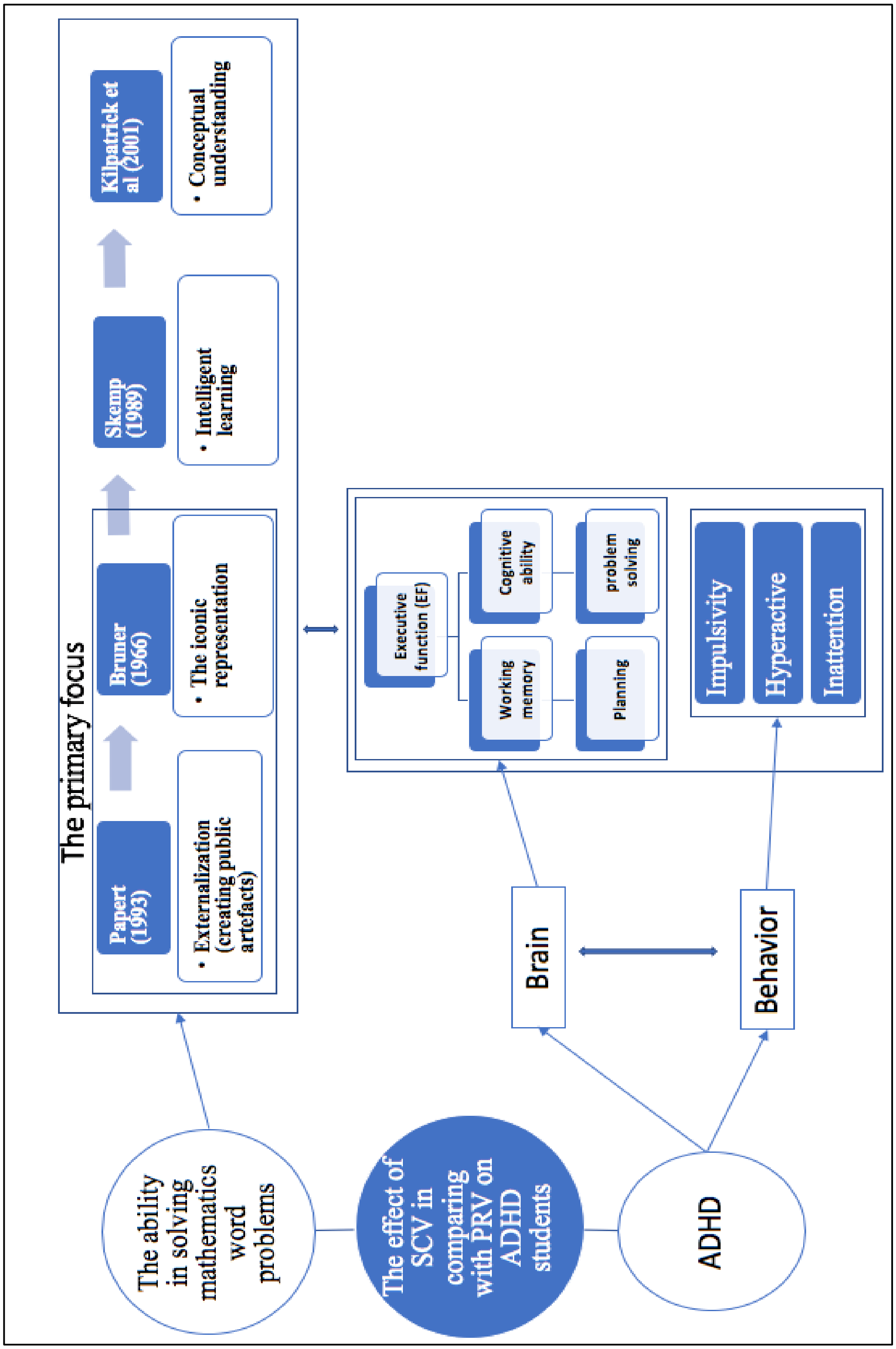


Figure 2.3 Conceptual framework

2.11 Research Aim and Questions

The research aim is to examine the effect of using PRV and SCV on students with ADHD by helping them access mathematical word problems. The research questions are as follows:

(1) To what extent do PRV and SCV help students with ADHD to solve mathematical word problems?

(2) To what extent do PRV and SCV help students with ADHD remain focused while solving mathematical word problems?

(3) What are the perceptions of children with ADHD of using PRV and SCV to solve mathematical word problems?

(4) What are teachers' perceptions of the influence of using SCV and PRV while solving mathematical word problems, and on the behaviour of students with ADHD?

2.12 Summary

This chapter has reviewed the literature to identify the main concerns explored in the current study. It started with the primary theory applied in this research (constructionism) and then discussed the secondary theories formulated from the primary theory (for example, the theory of mathematics learning, representation and visualisation). From all these theories, the main point of this study was developed, which is to examine how PRV and SCV affect the ability of students with ADHD to solve mathematical word problems. As the focus population of this study comprises students with ADHD, it is critical to consider the definition of ADHD and the theoretical perspectives linked with this diagnosis, in order to be able to devise the research questions and research design, which will be discussed in the next chapter.

CHAPTER 3: METHODOLOGY

3.1 Introduction

This chapter begins with a discussion of the study's adopted philosophical assumptions and research paradigm. It then explains the use of the explanatory mixed methods design and provides justification for using intervention experimental design, observation, surveys, and interviews as suitable tools for the data collection. Furthermore, it discusses the study's sample size and the adopted sampling techniques. In addition, this chapter discusses the data analysis, validity, reliability, and ethical considerations.

3.2 Philosophical Assumptions

Philosophical assumptions are the framework that shapes research (Hathaway, 1995; Creswell & Poth, 2017). For example, philosophical assumptions allow researchers to select directions for their study, develop research questions, gather data, and choose theories (Creswell & Poth, 2017). Additionally, philosophical assumptions can help in framing the research methodology and the keys aspects of the research such as developing the research assumptions, evaluating the results, and assessing the evidence (Andersen, Anjum & Rocca, 2019; Kumar, 2019). Similarly, Hathaway (1995) and Biedenbach and Jacobsson (2016) clarified that philosophical assumptions are beliefs that help researchers build their hypotheses. Therefore, philosophical assumptions are important for building a clear research foundation of how knowledge is created (Biedenbach & Jacobsson, 2016; Saunders, Lewis, & Thornhill, 2016; Kumar, 2019). It should be noted that scholars in the research field consider philosophical assumptions in three aspects (Scotland, 2012): ontology, epistemology, and methodology.

3.2.1 Ontology

Ontology has been defined by many researchers as the nature of reality (Seth, 2014; Biddle & Schafft, 2015; Coe, 2017; Fung & Bodenreider, 2019). The main concern of ontology for scientific inquiry is how the assumptions we make about reality, including what the mind is and the nature of observations made by scientists, affect how we think about and investigate the phenomena under study (Anderson & Biddle, 1991; Scotland, 2012; Blaikie & Priest, 2019; Fung & Bodenreider, 2019). There are two ontological stances of interest to this study: positivism and interpretivism, which could be referred to as subjective (qualitative research) and objective (quantitative research) (Maarouf, 2019). The former focuses on the assumption that there is one single truth, and reality can only be investigated by certain valid and reliable tools which yield empirical evidence (David & Sutton, 2011); positivism seeks the existence of facts (Brock & Mares, 2014; Bryman, 2016; Zyphur & Pierides, 2019) and is related to realism (David & Sutton, 2011; Zyphur & Pierides, 2019). Realism has been defined as an aspect of the ontological philosophy of the positivism position, which relies on clarifying the nature of scientific practice (Salvador, 2016); a similar definition by Blaikie and Priest (2019) can be found. However, some scholars, such as Donnelly (2019), have argued that realism is not fundamental, therefore it does not have a core definition because it is multidimensional, depending on the claims, actions, explanation, and the outcomes. Interpretivism, which is linked to relativism, highlights that reality depends on one's personal view through interaction (Scotland, 2012; Brock & Mares, 2014; Seth, 2014). Accordingly, there is no single truth because the participants themselves will construct the truth, and reality is interpreted through each participant's lens (Crotty, 2003; Coe, 2017).

The current research's ontological stance embraces both positivism and interpretivism because the current study's research questions comply with multiple philosophical stances. For example, the first and second research questions will aim to examine a realistic situation by providing an explanation and understanding of the effects of using PRV and SCV to develop the abilities of students with ADHD to solve mathematical word problems and the influences on their behaviour, using a quantitative approach that is based on objective data. On the other hand, the third and fourth research questions set out to explore children's and teachers' perceptions, thereby adopting the view that individually constructed knowledge and experiences are interpretative and cannot be presented through a single truth.

3.2.2 Epistemology

Epistemology or philosophical underpinnings of the research (McGannon, Smith, Kendellen, & Gonsalves, 2019) deals with questions about where and how knowledge is formed (Biddle & Schafft, 2015; Cohen, Manion, & Morrison, 2011; Seth, 2014; Albert, Mylopoulos & Laberge, 2019). The main concern of epistemology is to understand how knowledge can be obtained (Scotland, 2012; Seth, 2014; Bryman, 2016; Albert, Mylopoulos & Laberge, 2019). According to Bacci (2019), epistemological stance is concerned about how knowledge can be constructed through what we can observe and is not only reliant on statistical fact. From this point it could be noticed that there are two key epistemological stances relevant to the current study: objectivism and subjectivism. Objectivist epistemology, according to Scotland (2012), appeals to objectivity, which holds that "the researcher and the researched are independent entities" (p.10), where the truth exists independently and is explicitly conclusive (Shaw & Selvarajah, 2019). The second stance is subjectivist epistemology, which depends on relativism (Scotland, 2012; Seth, 2014). This holds that knowledge does not exist independently from what we know and is formulated from our interpretations and interactions (Scotland, 2012). Additionally, this stance of epistemology helps in developing the individual understanding about the research problem (Matney, 2019).

The current research's epistemological stance embraces both objectivism and subjectivism. In relation to the first and second research questions, objectivism is adapted to measure the students' development in solving mathematical word problems, along with the students' changing behaviour by using PRV and SCV; the reality will be investigated using quantitative methods (experiment and observations). In relation to the third and fourth research questions, the current study considers that each participant can have different implementations and views about the effects of using PRV and SCV in their mathematics classrooms. Therefore, the knowledge of the current study can be constructed by using interpretivism (Scotland, 2012), which suggests that reality can be constructed by different participants drawing from their different perspectives.

3.2.3 Methodology

Methodology is defined by Punch and Oancea (2014) as "what lies behind the approaches and methods of inquiry that might be used in a piece of research" (p.16); in other words, it is about asking "how can the inquiry go about finding out what can be known?" (p.17). A similar definition is provided by Crotty (1998) and Punch (1998), who both stated that methodology is about the approach or method that a researcher follows to investigate reality. Similarly, Mackey and Gass (2016) and Kumar (2019) pointed out that it is the guide for research processes and decisions. Additionally, Snyder (2019) discussed that research methodology is an approach help to build a good research contribution, Snyder (2019) also added that methodological decisions help in answering the research questions, how the research data can be obtained, and determine which research criteria can help in reviewing the data.

A variety of research methodologies depend on the purpose of the knowledge to be acquired, the data collection, and the nature of the inquiry. There are three types of methodological approaches: quantitative, qualitative, and mixed methods. The qualitative approach is identified as an approach that does not use numerical systems to collect and analyse data (Ritchie, Lewis, Nicholls, & Ormston, 2013; Punch & Oancea, 2014; Rahman, 2017) because the data build on interpretive processes and not statistical ones (Punch & Oancea, 2014; Mackey & Gass, 2016; Robson & McCartan, 2016). All research strategies, questions, procedures, and data collection methods depend on the participants' views (Maxwell & Mittapalli, 2010; Creswell, 2014), and this is the reason why this type of research is subjective and considered as inductive (Hennink, Hutter, & Bailey, 2020). Some examples of qualitative research methodology are case study and grounded theory which are using deep interviews and qualitative observation or surveys (Aguinis & Solarino, 2019; Hennink et al., 2020).

Qualitative research has many advantages; for example, the reality under investigation is interpretive because the research relies on multiple realities or aspects (see subsection 3.2.1 on ontology), because it can provide details about the issue of research and human experiences, and because it can develop new ideas which may not be apparent in the quantitative data or literature (Wilson, 2014; Mackey & Gass, 2016; Rahman, 2017). The disadvantage of using the qualitative approach is that the results cannot be generalised because the data are not standardised and sample sizes for qualitative studies are often small; meanwhile, the qualitative approach depends on people's views, so the data are highly subjective and easily biased. This can lead to low credibility of the result because it focuses on the meaning that emerges from people's opinions (Cohen et al., 2011; Creswell, 2014; Rahman, 2017). Two examples of qualitative data collection methods are interviews and unstructured observations (Punch & Oancea, 2014).

In contrast, the quantitative approach can be defined as research based on specific research hypotheses which deal with numbers or measurements (Cohen et al., 2011; Punch & Oancea, 2014; Mackey & Gass, 2016). The quantitative approach uses deductive logic by using statistical, positivist methods and assuming the existence of an objective reality (Mackey & Gass, 2016; Rahman, 2017). Quantitative methods can be conducted by using questionnaires with close-ended questions, structured observations, and experiments (Mackey & Gass, 2016; Rahman, 2017). The advantage of using quantitative research is that findings can be generalised, as it generally uses large, randomly selected samples (Ritchie et al., 2013; Creswell, 2014; Rahman, 2017). This can lead to having a stable view of reality because the data are arguably more objective (Mackey & Gass, 2016). However, a disadvantage of using quantitative research is that it does not provide deep explanations for meanings and does not show how people interpret their actions (Cohen et al., 2011; Rahman, 2017).

The third methodological approach, mixed methods, is selected as a suitable approach to serve the current study's inquiries. By using mixed methods, the strength of the study will be increased by making use of the advantages of both quantitative and qualitative methods while avoiding their limitations. This can be achieved by using triangulation (using different methods to collect data and combine them in relation to the same topic being studied; Creswell & Plano Clark 2011; Edmonds & Kennedy, 2017; Creswell & Hirose, 2019).

The current study seeks to find relationships between research variables and oriented outcomes of the research by examining and testing the objective of the theory (comparing two kinds of visualisation in learning mathematics, the independent variable, on how these affect the children's problem-solving performance, the dependent variable). To explore the effects of using PRV and SCV on the ability of students with ADHD to solve mathematical word problems, the notion of whether using visualisation affects mathematical ability in word problems and the behaviour of these students will be tested using an experimental design and observation. This will address the first and second research questions. Moreover, the study aims to determine the children's and teachers' views, which is one characteristic of qualitative research (Punch & Oancea, 2014; Mackey & Gass, 2016; Rahman, 2017) and will be done by conducting semi-structured interviews to address the third and fourth research questions.

3.3 Research Paradigm

A research paradigm is a theoretical framework built from philosophical (ontological, epistemological) and methodological (qualitative, quantitative, and mixed methods) assumptions generated by research questions (Morgan, 2014; Fellows & Liu, 2015; Coe, 2017; Roth & Rosenzweig, 2020). Additionally, research paradigm is a research guide to think about the world and the experiences from that world to provide some explanations and make some practical decision about the research strategy (Schoonenboom, 2017; Kankam, 2019). It could be argued that the main purpose of a research paradigm is to investigate the reality by using the method that best suits the research problem (Cohen et al., 2011; Poni, 2014; Fellows & Liu, 2015; Kankam, 2019). Moreover, Fellows and Liu (2015) and Kankam (2019) pointed out that using a paradigm is important for adopting an appropriate research design to answer the research questions and build the research character. According to Kankam (2019) there are different types of research paradigm; pragmatism, interpretivism, positivism, and post-positivism and these are the most widely research paradigm used in research. The choice between these paradigms depend on the natural of the research question which can shape the research methodology (Kankam, 2019; Roth & Rosenzweig, 2020).

As the current study used a mixed methods approach, pragmatism can be a suitable paradigm, as it is generally appropriate for this research (Tashakkori & Teddlie, 2003; Feilzer, 2010; Creswell, 2014). Pragmatism constitutes different philosophical assumptions (epistemology and ontology), which form an integration of positivism and interpretivism, in which positivism reflected using objectivism and interpretivism reflected using subjectivism (Tashakkori & Teddlie, 2003; Creswell, 2014). The following section will provide more details about the pragmatic paradigm.

3.3.1 Pragmatism

The association between pragmatism and mixed methods has been supported by many researchers and theorists (Tashakkori & Teddlie, 2003; Feilzer, 2010). Kankam (2019) seems to believe that pragmatism "shared meanings as well as joint actions" (p.86). However, Robson and McCartan (2016) viewed the pragmatic paradigm as more practical than theoretical; they defined it as trying to determine what works best to solve a research problem. The advantage of using pragmatism as a paradigm for this study is that it will help avoid the dichotomy between positivism and interpretivism by employing multiple research approaches (i.e. quantitative and qualitative). These mixed positions can improve the likelihood that the research questions will be fully answered. In addition, using pragmatism adds more value to the design by highlighting the strengths of each method and lessening its drawbacks; this is achieved by integrating two different research approaches (qualitative and quantitative; Feilzer, 2010; Creswell, 2014), which provides the current research with the element of triangulation.

The aim of this study is to explore the reality of the knowledge by investigating the effect of using PRV and SCV for improving the ability of students with ADHD to solve mathematical word problems. Thus, the pragmatic view is suitable for the research inquiries because it presents a better understanding of the truth and acceptance of dualism (for example, mixing realism with idealism; see Brock & Mares, 2014; Creswell, 2014). In the current study, the data resulting from an intervention experimental design followed by semi-structured interviews with the students who have ADHD and their teachers supported the validity of the results gained from the experiment and will help explain how these students construct mathematical knowledge, using PRV and SCV. The findings from the various data resources can complement each other, thereby providing rich and detailed results.

3.3.2 Mixed Methods Approach

The mixed methods design can be defined as the association between qualitative and quantitative research (Punch & Oancea, 2014; Bryman, 2016); it explores and answers questions using both qualitative and quantitative approaches and beliefs (Punch & Oancea, 2014; Mackey & Gass, 2016). Bryman (2016) argued that mixed methods research is not only about combining two research methods (qualitative and quantitative) but is also about providing a complete understanding of the research problems (Creswell, 2014). The research questions require an interpretation between the objective data about the ADHD students' progress in mathematical word problems and changes in their behaviour through using PRV and SCV (Research Questions 1-2), while the subjective data reflect students' and teachers' views about the experience of using PRV and SCV (Research Questions 3-4). Thus, the mixed methods approach will allow the incorporation of different research perspectives and the selection of the best method to answer the research questions (Creswell & Plano Clark, 2011; Bryman, 2016).

Creswell, Plano Clark, Gutmann and Hanson (2003) and Edmonds and Kennedy (2017) have identified some different types of mixed methods approaches—namely, the convergent parallel approach, in which qualitative and quantitative data are collected separately at the same time; the embedded approach, which "is the nested approach and is used when one type of data (QUAN or QUAL) is most critical to the researcher" (p.189); the explanatory sequential approach, which starts by collecting and analysing the quantitative data followed by collecting and analysing the qualitative data in order to provide support in explaining the interpretation of the quantitative data by using the qualitative data; and the exploratory sequential approach, in which the process begins with quantitative research in phase one, conducts both quantitative and qualitative research in phase two, and finally interprets all the findings of the analysis. As the current research will focus on examining the effects of using RPV and SCV on the mathematical word problem-solving ability and attentional behaviour of students with ADHD, a sequential explanatory design is suitable for this research inquiry, as will be explained next.

The study initially collected and analysed quantitative data by using an experimental design and structured observations to answer the first, second, and first part of the fourth research questions. This was followed by obtaining qualitative data (to answer the third and the second part of the fourth research questions) by conducting interviews and analysing the transcriptions to provide assistance or support in explaining and interpreting the quantitative findings (Creswell et al., 2003; Creswell & Plano Clark, 2011; Edmonds & Kennedy, 2017). The use of the qualitative data can be viewed as an aspect of triangulation to examine the consistency among the four types of data (experiment, observation, surveys and interviews). Triangulation of the data may draw attention to unexpected results that appear during the qualitative or quantitative approach which would otherwise go unnoticed (Creswell et al., 2003). Cohen et al. (2011) explained that “triangular techniques in the social sciences attempt to map out, or explain more fully, the richness and complexity of human behaviour by studying it from more than one standpoint” (p.195).

3.4 Research Design and Data Collection

The research design refers to the strategies and plans used to execute the research (Punch & Oancea, 2014); these serve to build an investigation to answer the research question or problems and report the results (Kumar, 1999; Creswell & Plano Clark, 2011; Creswell, 2014). This study used a sequential, explanatory mixed methods design which involved the quantitative method (experiment, structured observation, and surveys) and then the qualitative method (semi-structured interviews). This design was briefly noted in subsection 3.3.2 and is examined in more detail in the following sections.

The research design in the pilot study is different than the one used in the main study. As the initial thought was that there would be only a few children with ADHD in the participating schools, a multiple baseline design was used as a suitable experiment design for small numbers of participants. However, it became apparent during the pilot study at the participating schools that there were actually several more ADHD children than previously thought; hence, the experiment design was shifted from multiple baseline to a simple experimental design.

In addition, the pilot study used two different apps: one for SCV and one for PRV (for more details about these apps, see 2. Pilot Study Plan in Appendix 1). Nevertheless, the idea of using apps for the daily sessions shifted to using a simple booklet with word problems for SCV and word problems and images for PRV because using apps was time-consuming and the sources for images were limited; it was also difficult to provide scores for each student. Furthermore, there were many uncontrollable features when using the apps, and the participants could not use these apps for the main study. Examples of challenges included that the tablets or iPads may not be charged enough, there may be some technical problems with apps, and the students' motivation for learning the topic may vary.

3.4.1 Pilot Study Design

The main aim of conducting a pilot study is to test the validity and reliability of the research instruments and gather feedback regarding the suitability of the instruments. The sample size for the pilot study was four 9-11 year-old (2 girls, 2 boys) students with ADHD, who were equally and randomly assigned to the SCV or PRV group. Two apps were used in order to examine SCV and PRV. Keynote was used for SCV, where the students can construct their drawing to represent the situations given in mathematical word problems. The other app was Make, used for PRV where the students are given images to represent situations in mathematical word problems (for more details about these apps see 13. Plan of Experimental Sessions in Appendix 1). The pilot study started with a pre-test and pre-test interviews, followed by a multiple baseline experiment; finally, the post-test and post-test interviews and the delayed test were administered (more details about the pilot study design can be found in Appendix 2. The Pilot Study). During the intervention sessions, observations were collected through videos. The challenges encountered and the additional information gathered while conducting the pilot study implied some changes in the main study plan (see the challenges and implications of the pilot study in Appendix 2).

Conducting the pilot study resulted in many benefits. First, it allowed for a better understanding of the research process by developing an understanding of the research instruments (i.e. SCV and PRV), highlighting the strengths and weaknesses of each (see Appendix 2). In addition, the pilot study improved and clarified the research aim and questions by providing an understanding of the application of PRV and SCV and how both work with students to shape their understanding of mathematical word problems. The pilot study also helped acquire some ideas on suitable research design and data collection methods. For example, adding note-taking during SCV and PRV sessions gave clear indications about how the students can deal with each problem and how a child can be developed by using SCV and PRV (see Appendix 2 for information on the implementation of open-ended observations). Finally, the pilot study gave a clear idea and focus on what the study intended to do, thereby reflecting on some elements of validity and reliability of the main study. Furthermore, testing the study instruments, such as the observation sheets, helped understand its efficacy in observing students' behaviour; testing SCV also helped identify the number of questions required within the timeframe and develop the image quality for PRV to be clear when presenting the word problems (see Appendix 2 for information on the challenges and implications of the pilot study).

One of the challenges encountered was that some students abandoned the study because they did not like drawing and refused to draw. This suggested the need to give more freedom to students when drawing by discarding the apps and using a booklet instead because the apps were restrictive for students by not providing enough space to draw and for the research by limiting resources, especially in PRV. In addition, designing every session using apps was very hard and time-consuming work; using a booklet with questions was easier (see Table 3.5). As many students in the SCV group seemed confused about what to do and what to draw, having an introductory session for the SCV group (the intervention group) about what kind of drawing should be created, (see 11. Introductory Session in Appendix 1 for more explanation of the introductory session).

The number of questions were reduced from 10 to 6 because the students in the pilot study could not finish solving 10 word problems in 30 minutes. As using open-ended observations and note-taking (see Appendix 2 for more information) helped understand the extent to which using SCV or PRV was clear for the students and helped them solve mathematical word problems, a similar strategy was used in the main study to support the main study results. Finally, the experiment design was changed from a multiple baseline design to an intervention experiment design because more students than expected participate. Thus, using an intervention experiment design was possible with the current sample size.

3.4.2 Main Study Design

3.4.2.1 Quantitative Approach

3.4.2.1.1 Experimental Design

The first part of the study set out to address the first research question (*To what extent do PRV and SCV help students with ADHD to solve mathematical word problems?)* and adopted an experimental design. The term *experiment* refers to the situation of understanding causes and their effects by systematically changing the relationship between different variables and observing their changes (Cohen et al., 2011; Barker & Milivojevich, 2016; Montgomery, 2017). The experimental design was used to investigate and explore the effect of using different types of visualisation (PRV and SCV) on the ability of students with ADHD to solve mathematical word problems. This led to proposing hypotheses or theories about the system under investigation (Barker & Milivojevich, 2016; Montgomery, 2017). Specifically, the following hypotheses were generated for the current research:

(1) There are no significant differences between the effects of PRV and SCV on the ability of students with ADHD to solve mathematical word problems (the null hypothesis).

(2) There are significant differences between the effects of PRV and SCV on the ability of students with ADHD to solve mathematical word problems (the alternative hypothesis).

In an experimental research design, the purpose is to control and measure the changes of one or more variables (independent variables) to investigate the effect on other variables (dependent variables). In the current study, the independent variable was the type of visualisation (PRV vs. SCV) used in learning to solve mathematical word problems; the dependent variable was the students' ability to solve mathematical word problems and their attentional behaviour.

The current study adopted an intervention experiment design to explore which type of visualisation affected the ability of students with ADHD to solve mathematical word problems. The intervention design for the current study included two equal groups: the intervention group (SCV) and the comparison group (PRV) as it shown in Tables 3.1 and 3.2. The students were randomly allocated to the groups (SCV and PRV) depending on the pre-test scores (high, medium and low), with each group containing students with high, mid, and low scores. The students in both the control and intervention groups used the two types of visualisation (SCV and PRV) for the same length of time (four weeks, equivalent to 20 sessions) as clarified in Tables 3.1 and 3.2, demonstrating the effect of using SCV to solve mathematical word problems for each ADHD student.

Table 3.1 Effect of using SCV on the comparison (control) group

Control Group (PRV): 4 girls and 6 boys

Week	Sessions
1	1–5
2	6–10
3	11–15
4	16–20

Table 3.2 Effect of using SCV on the intervention group

Intervention Group (SCV): 4 girls and 6 boys

Week	Sessions
1	1–5
2	6–10
3	11–15
4	16–20

This intervention study by group comparison experiment not only helped address the efficacy and effectiveness of using SCV as an intervention with ADHD students when solving mathematical word problems, but also expanded the knowledge of educational practice by improving mathematical achievement and cognitive abilities and managing ADHD behaviour. Adopting intervention research can help improve the findings and outcomes by providing a clear picture of the implementation of SCV on ADHD students' mathematical abilities and behaviour management, compared to using PRV.

3.4.2.1.2 Procedure for Collecting the Experiment Data

As discussed in the pilot study section, after the pilot study, an experiment was conducted to gather the data necessary to understand how SCV (intervention) might help students solve mathematical word problems. According to Papert’s (1993) theory of constructionism, children can solve mathematical problems more effectively by externalizing their thinking by creating a public artefact, which was achieved in this study by representing word problems by creating drawings (SCV) to visually illustrate the problems.

The intervention was conducted during the first term of the academic year in Kuwait. The academic year in Kuwait is divided into two terms; the first term runs from September to mid-January while the second term runs from the end of January to the beginning of May. In September and October 2018, eight ADHD students in a primary school for girls with learning disabilities (School G) participated in the experiment. The students were equally and randomly divided into two groups: four students in the intervention group (SCV) and four students in the comparison group (PRV). In November and December 2018, 12 ADHD students in a primary school for boys with learning disabilities (School B) participated in the experiment. Again, these students were equally and randomly divided into two groups: six students were in SCV (intervention group) and six were in PRV (comparison group). Thus, a total of 20 students with ADHD participated, 10 in the intervention group and 10 in the comparison group. Each student completed 20 one-to-one 30-minute sessions. Before the experiment started, the intervention group received an introductory session to make sure they understood the purpose of the intervention and what solving mathematical word problems by drawing means. All students completed the same tests: a pre-test, a post-test, and a delayed post-test administered one month after the post-test. In addition, students completed four tests after every five sessions (see Table 3.3 for further clarification about the experimental design).

Table 3.3 Design of the experiment

SCV	Pre-test	Test 1	Test 2	Test 3	Test 4	Post-test	Delayed test
10 students (4 girls and 6 boys)		After 5 sessions	After 10 sessions	After 15 sessions	After 20 sessions		One month after the post-test
PRV	**Pre-test**	**Test 1**	**Test 2**	**Test 3**	**Test 4**	**Post-test**	**Delayed test**
10 students (4 girls and 6 boys)		After 5 sessions	After 10 sessions	After 15 sessions	After 20 sessions		One month after the post-test

In Table 3.4, examples are presented from the pre-test, post-test, delayed post-test and test questions, translated from Arabic to English by a professional translator.

Table 3.4 Translated excerpts from the pre, post-, and delayed post-tests

Test	Translation of the Test Questions
Pre-test  Pre-test exam اسم الطالب: الصف: التاريخ: السؤال الأول دفع الاب ١٠٠دينار للفندق لقاء الإقامة ل ١٠ ليالي. ما المبلغ الذي دفعه الاب للإقامة الليلة واحدة؟ السؤال الثاني إذا كان أحمد يقطع مسافة وقدرها ٢ كلومتر للذهاب للمدرسة يوميا. فما المسافة التي يقطعها أحمد للذهاب الى المدرسة خلال خمسة أيام؟ السؤال الثالث لقد قررت مديرة المدرسة ترتيب الطلبة لطابور الصباح على شكل طف عامودي و٣صفوف افقية. إذا علمت ان عدد الطلبة في الصف العامودي هو ٣٥ طالب وفي الصف الافقي ٢٠ طالب. كم عدد الطلبة في طابور الصباح؟ السؤال الرابع قررت ريم أ ن تساعد والدتها في ترتيب علب العصير لعيد ميلاد اختها. كان مجموع عدد علب العصير هو ٢١ علبة. فاذا إرادة ريم ترتيبها في ٣ صفوف، فعلى كم علبة عصير سوف يحتوي كل صف؟ السؤال الخامس قررت الهيئة العامة للبيئة في الكويت ان تحصي عدد رمي النفايات. اذا كانت عائلتك مكونه من ٤ اشخاص وكان معدل مجموع رمي النفايات هو ٢١٢ كجم في الأسبوع. فلو اردت تقسيم هذه النفايات على افراد عائلتك بالتساوي. فكم كجم رمى كل شخص خلال الأسبوع؟ السؤال السادس وضعنا بعض الفواكه في عدد من السلال. يوجد ٣ حبات برتقال و٢ حبة تفاح في كل سلة. مجموع حبات الفواكه ٤٥ حبة. ما هو عدد حبات التفاح؟ انتهت الأسئلة شكرا	First question: The father paid 100 dinars to the hotel for a stay of 10 nights. How much did he pay for a one-night stay? Second question: If Ahmed travels 2 km to go to school every day, what distance does Ahmed travel to school in five days? Third question: The headmaster has decided to arrange the students in a morning queue, in the form of 1 vertical and 3 horizontal lines. If you know that there are 35 students in the vertical line, and 20 students in the horizontal line, how many students are in the morning line? Fourth question: Reem decided to help her mother arrange juice cans for her sister's birthday. The total number of juice cans was 21. If Reem arranged them in three rows, how many cans of juice were there in each row?

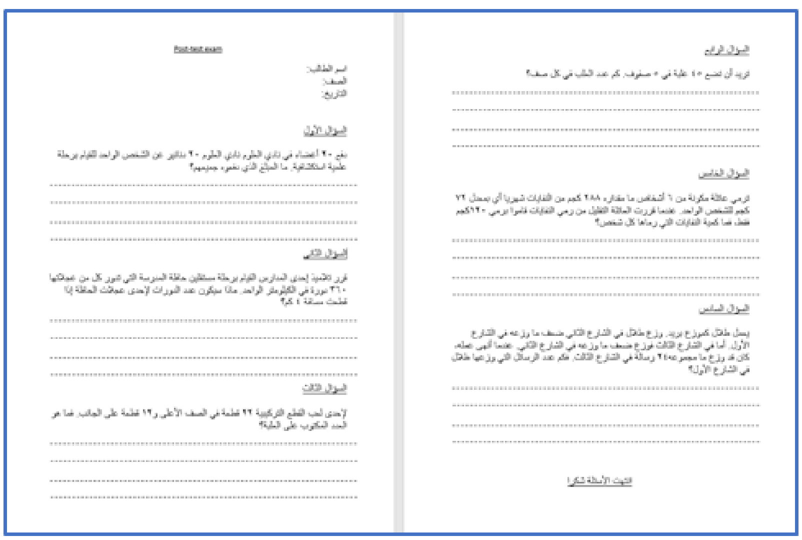
Fifth question:

Kuwait's General Authority for the Environment has decided to count the number of waste dumps in Kuwait per week. There are four people in your family and the average total waste dumped is 212 kg per week. If you divide this amount of waste equally among the members of your family, how many kilograms does each person throw away every week?

Sixth question:

We put some fruit in a number of baskets. There are three oranges and two apples in each basket. There are 45 pieces of fruit in total. How many apples are there?

Post-test



First question:

10 members of the Science Club paid 10 dinars per person for an exploratory scientific trip. How much did they all pay in total?

Second question:

The pupils in a school decided to take a trip using the school bus. The bus wheels rotate at 360 cycles per kilometre. How many times will the bus wheels rotate, if it travels eight kilometers?

Third question:

For one of the Lego pieces box, 42 pieces were played in the top row and 26 pieces on the side. What number is written on the box of Lego pieces?

Fourth question:

You want to arrange 15 boxes in three rows. How many boxes can you include in each row?

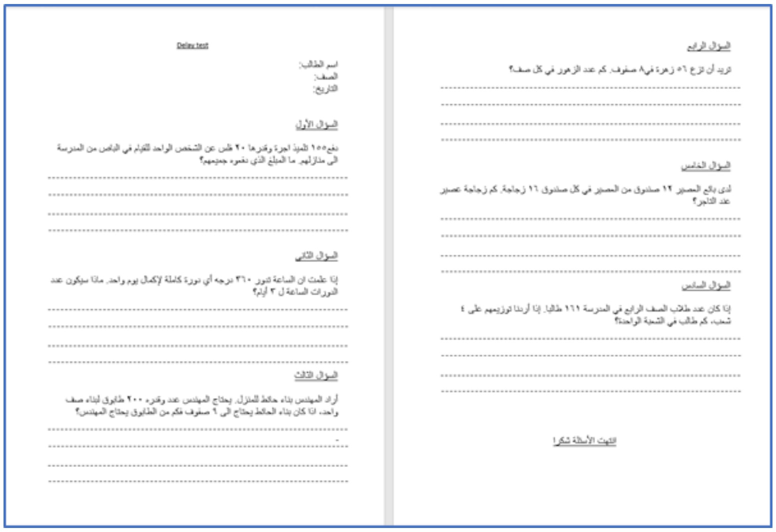
Fifth question:

A family of four throws out 288 kg of waste per month, which is an average of 72 kg per person. When the family decide to cut back and dump just 211 kg, how much waste does each person throw away?

Sixth question:

Talal works as a mailman. He distributes twice as much mail on the second street as he does on the first street. On the third street, he distributes twice as much mail as he does on the second street. By the time he finishes his work, he has distributed a total of 24 messages on the third street. How many messages does Talal distribute on the first street?

Delayed post-test


Delay test

اسم الطالب:
الصف:
التاريخ:

السؤال الأول

دفع١٥٥ تلميذ اجرة وقدرها ٢٠ فلس عن الشخص الواحد للقيام في الباص من المدرسة الى منازلهم. ما المبلغ الذي دفعوه جميعهم؟

السؤال الثاني

إذا علمت ان الساعة تدور ٣٦٠ درجه أي دورة كاملة لإكمال يوم واحد. ماذا سيكون عدد الدورات الساعة ل ٣ أيام؟

السؤال الثالث

أراد المهندس بناء حائط للمنزل. يحتاج المهندس عدد وقدره ٢٠٠ طابوق لبناء صف واحد. اذا كان بناء الحائط يحتاج الى ٩ صفوف فكم من الطابوق يحتاج المهندس؟

السؤال الرابع

تريد أن تزرع ٥٦ زهرة في٨ صفوف. كم عدد الزهور في كل صف؟

السؤال الخامس

لدى بائع العصير ١٢ صندوق من العصير في كل صندوق ١٦ زجاجة. كم زجاجة عصير عند التاجر؟

السؤال السادس

إذا كان عدد طلاب الصف الرابع في المدرسة ١٦١ طالبا. إذا أردنا توزيعهم على ٤ شعب، كم طالب في الشعبة الواحدة؟

انتهت الأسئلة شكرا

First question:

155 students paid a fee of 20 fils per person to take the bus from school to go home. How much did they pay in total?

Second question:

If you know that the clock rotates 360 degrees to complete one cycle for one day, how many cycles will be completed for three days?

Third question:

An engineer wanted to build a wall for a house. He needed 200 bricks to build a row. If nine rows are required to build the wall, how many bricks does the engineer need?

Fourth question:

You want to plant 56 flowers in eight rows. How many flowers will you plant per row?

Fifth question:

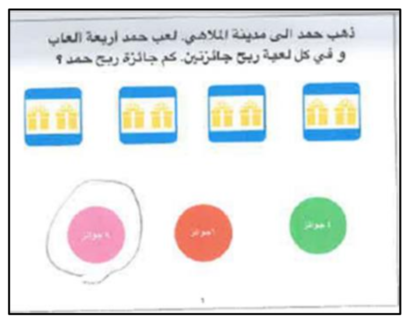
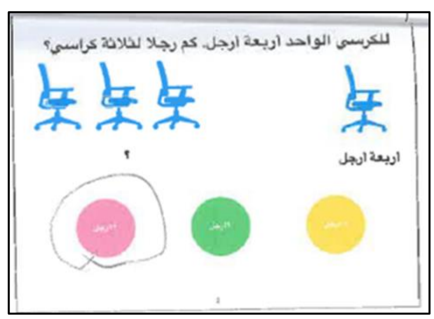
A juice seller has 12 boxes of juice. In each box, there are 16 bottles. How many bottles of juice does the dealer have?

	<u>Sixth question:</u> If there are 161 students in the fourth grade of your school, and we want to distribute them to four classes, how many students will we have in each class?

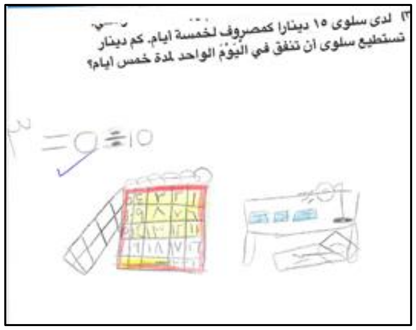
In order to maintain participants' privacy and reduce any potential harms and biases the participants might experience (Finn, 2016; Brear, 2017), all students' names used herein are pseudonyms. The students were assigned numbers (referring to individual students), letters (referring to either School B or School G), and the group (SCV or PRV), for example, student 1-B-SCV or student 7-G-PRV. The decision to use pseudonyms was made partly due to Brear (2017), who pointed out that "due to the challenges of allowing participants to choose their own names (for example, what to do if two choose the same name) researchers may select pseudonyms themselves" (p.723). Furthermore, as a part of the ethical procedures, both schools' head teachers received an information letter detailing the nature of the request and the purpose of the study; participants' parents received a similar letter. Both head teachers and parents also received copies of the consent forms, and copies of children's consent forms were delivered to the participants (i.e. students with ADHD). A total of 30 students with ADHD were invited to participate in the study from both schools (girls' school and boys' school), but 10 students did not agree to take part in the study, thereby leaving 20 students who participated.

Decisions about the type of sessions and test question used in this study were made with the agreement of the mathematics teachers from both the sampled schools. Their agreement was necessary to ensure that the mathematical word problems used in the sessions and tests corresponded to their curricula. Thus, before the experimental phase began, the researcher travelled between the two schools to set the test questions. Once the test questions had been designed, the researcher sat with the teachers from each school to develop the session questions on the day before each session. This helped the researcher verify that the sessions and test questions were all suitable for the students' mathematics curriculum in each of the learning disability schools. Consequently, the questions in all the tests and sessions started with the easiest, followed by those of medium difficulty, and ending with the most difficult. Some examples of session questions and the ways in which the students solved mathematical word problems using SCV and PRV are illustrated in Table 3.5.

Table 3.5 Example of three questions from one of the sessions

<table>
<tr><th>Session questions (three examples)</th><th>Example from one of the SCV students</th><th>Example from one of the PRV students</th></tr>
<tr><td>1. Hamad went to the theme park. Hamad played four games and, in each game he won two prizes. How many prizes did Hamad win?</td><td>
</td><td>
</td></tr>
<tr><td>2. One chair has four legs. How many legs do three chairs have?</td><td></td><td>
</td></tr>
</table>

3. Salwa has 15 dinars for five days. How many dinars can Salwa spend per day for those five days?



3.4.2.1.3 Observation

To answer the second research question (*To what extent do PRV and SCV help students with ADHD remain focused while solving mathematical word problems?*), the children's behaviour throughout the experiment was recorded. Observation allowed particular events that participants may not feel comfortable talking about in interviews to be studied (Cohen et al., 2011). There are three types of observation: structured observation (quantitative observations lie in counting events), non-structured observation (qualitative observation depends on taking notes and developing narratives from the observed behaviour), and semi-structured observation (gathering data in a systematic way through note-taking and a categories agenda; Cohen et al., 2011; Bryman, 2016).

The current study observed how using PRV and SCV affects ADHD behaviour while solving mathematical word problems through the use of video recordings. Such observation was structured (quantitative observation) by following scheduled categories that shape the observation in counting the events (Bryman, 2016). The observation categories have been developed using the DSM-5 (see Table 3.6) to observe behavioural changes in children with ADHD concerning inattentions, hyperactivity, and impulsivity while using PRV and SCV in mathematics lessons to solve word problems. Observing inattentions is divided into seven categories, and hyperactivity and impulsivity are divided into six categories. The main goal is to see if these categories change (decrease, remain the same) by using PRV and SCV with students with ADHD during the 20 sessions. This enabled the researcher to assess the impact of using these two forms of visualisation (PRV and SCV) to solve word problems on ADHD behaviour more accurately.

Table 3.6 Structured observation categories: ADHD behaviour for DSM-5

Inattention	**Hyperactivity and Impulsivity**
Missing details and the work are inaccurate	Taps hands or feet
Difficulties remaining focused on tasks	Squirms in the seat
Mind seems elsewhere	Often leaves the seat, does not remain seated
Easily distracted	Runs or climbs in inappropriate situations
Difficulties organising the task	Uncomfortable remaining still for extended time
Avoids engagement in tasks	Talks excessively
Forgets daily activities	

3.4.2.1.4 Procedure for Collecting the Observation Data

The observation focused on three ADHD behavioural aspects (i.e. inattention, hyperactivity, and impulsivity) which were drawn from DSM-5. The students in each of the two groups (SCV and PRV) were observed one-to-one across 20 sessions (30 minutes per each session) to identify occurrences of those ADHD behavioural aspects. Observations were conducted from the end of September to the end of October in the girls' school and from the beginning of November to the beginning of December in the boys' school. Each student in each group (8 in girls' groups, and 12 in boys' schools) was observed independently. The observation sheet was designed to observe the seven elements of inattention and six elements of hyperactivity and impulsivity (see Table 3.7). The observation data indicated occurrences of each element of an ADHD behaviour. For example, if a behaviour occurred for the element "Taps hands or feet", it was marked as 1; if it did not occur, it was marked as 0.

Table 3.7 Observation elements for inattention and hyperactivity/impulsivity

Inattention	**Hyperactivity and Impulsivity**
Missing details and the work are inaccurate	Taps hands or feet
Difficulties remaining focused on tasks	Squirms in the seat
Mind seems elsewhere	Often leaves the seat, does not remain seated
Easily distracted	Runs or climbs in inappropriate situations
Difficulties organising the task	Uncomfortable staying still for an extended time
Avoids engagement in tasks	Talks excessively
Forgets daily activities	

Although hyperactivity and impulsivity could be easily identified, some elements of inattention (for example, missing details and inaccurate work, difficulties organising the task, forgetting daily activities) were not as easy to observe; thus, inferences had to be made, which could arguably affect the reliability of the observations. These inferences were made for such elements because some students could correctly solve mathematical word problems without showing any details or organisation for that solution. Ultimately, it was quite confusing about whether these elements should be predicted or not. Therefore, notes were taken to record all questions the students asked during the sessions, thereby supporting the observations from the videos, especially for the difficult elements to be observed; some examples are shown in Appendix 3. The researcher also reviewed the videos twice to ensure that she observed what was supposed to be observed.

Therefore, students scored zero for “forgets daily activities” if they remembered exactly what they had to do and did not ask any questions about the activity. They scored 1 for “missing details and the work is inaccurate” if they said “there is not enough information”, indicating he/she missed some of the problem information, which was complete, or if the student counted the objects in the picture or drawing incorrectly or drew part of the problem and forgot the other part or reacted similarly when using pictures. In addition, for the element “difficulties organising the task”, students scored 1 if they looked confused while counting/recounting or drawing again and again, then selecting the incorrect answer.

The observation data were collected from videos of each student recorded for each session for 20 to 30 minutes of the one-to-one intervention sessions. These videos were recorded by the school’s technical and resources department because both schools preferred to keep the recordings in their archives to maintain the confidentiality of their students. Therefore, at the end of the sessions each day, the observations of each student were analysed in the Technical and Resources Department room.

After completing the data collection, the researcher realised that it would be difficult to analyse so many ones and zeros in the data. Therefore, the ratio of each observation element was calculated for each week and day, depending on the appearance of the behaviour, divided by the total number of students; for more information about how to calculate the ratio, (see sub-section 5.2.2.1.)

3.4.2.1.5 Surveys

The main objective for collecting the data by using a survey was to collect more data about the students' mathematical word problem-solving ability and the changes in their behaviour by using SCV or PRV. According to Brace (2018), the main job of the survey is to ask specific questions to collect specific answers. In the context of the current study, two surveys were developed to ask specific questions about the students' mathematical word problem-solving ability and their behaviour—one before applying the intervention and one after applying the intervention—to understand how the student improved in mathematical word problem-solving ability and how their behaviour had changed. In addition, one of the objectives for using the survey was to provide supporting data to the experiment and observation results.

There are different types of surveys or questionnaires depending on the structure (structured, semi-structured, and open survey) of the survey (Cohen et al., 2007; Brace, 2018). As the main goal of the survey in the current study was to compare teachers' perceptions before and after applying the intervention, using structured surveys was suitable to answer the fourth research question. As structured closed-question surveys or questionnaires can help provide clear numerical and frequency responses (Cohen et al., 2011), a clear statistical analysis can be provided. Using a questionnaire offers many advantages, such as saving time and money and being able to reach a wider range of people and areas, but it also has some disadvantages. For example, Brace (2018) indicated that bias and inaccurate data could be one of the major disadvantages of using surveys or questionnaires. Therefore, testing the reliability with the Cronbach's alpha value was necessary to avoid ambiguity in the question. As the idea of using the survey developed while applying the intervention, there was no time to pilot the surveys.

3.4.2.1.6 Procedure for Collecting the Survey Data

This section provides an overview of teachers' perceptions of the impact of using the intervention tool (i.e. SCV) on the ability of students with ADHD to solve mathematical word problems and on their behaviour, comparing the results with the use of PRV. Teachers' perceptions were collected via two surveys; the first survey elicited teachers' perceptions of the ADHD students' mathematical word problem-solving ability and their behaviour before the intervention, and a similar survey elicited teachers' perceptions of ADHD students' mathematical word problem-solving ability and their behaviour after the intervention.

Both surveys were conducted in January 2019, after the intervention had been accomplished in both schools. The class teacher for each of the students with ADHD participating in the study was invited to complete the survey and return it to the researcher before the end of January. These teachers received copies of the cover letters and consent forms as well as copies of the survey instrument. In total, 10 mathematics teachers participated: 5 teachers in the girls' school and 5 teachers in the boys' school. All were females (only females teach in Kuwaiti primary schools, and males teach in only very few schools), and the majority were in their 30s. The primary goal of these surveys was to support the data and the results from the intervention sessions and the 4 weeks of observations. Prior to the survey data collection, the survey questions were examined to check for errors, and any errors identified were corrected by the researcher. To make it easier for participants, the surveys included just one question in each row (see Appendix 6).

Each survey was designed to take around 5 minutes to complete. Survey participants answered the questions using a 5-point scale, where 1 is *Totally disagree*, 2 is *To some extent I disagree*, 3 is *I am not sure*, 4 is *To some extent I agree*, and 5 is *Totally agree*. As the surveys were designed to support both the intervention and the observation data, and both were created in two parts: ADHD students' mathematics skills to solve mathematical word problems and ADHD students' behaviour (see Appendix 6).

3.4.2.2 Qualitative Approach

<u>3.4.2.2.1 Semi-structured Interviews</u>

To address the third research question (*What are ADHD children's perceptions of using PRV and SCV to solve mathematical word problems?*) and fourth research question *(What are teachers' perceptions of the influence of using SCV and PRV while solving mathematical word problems, and on the behaviour of students with ADHD?),* semi-structured interviews were used. An interview generates data through conversation by asking questions (Cohen et al., 2011; Zohrabi, 2013; Lichtman, 2014). A semi-structured interview can be defined as an interview whose structure is determined by the researcher, depending on the research interest or hypothesis, while giving the participants the freedom to respond and describe their experiences in a narrative way (Cohen et al., 2011; Brinkmann, 2014).

The fundamental reason for using semi-structured interviews in this study was to provide in-depth information (Cohen et al., 2011; Zohrabi, 2013; Lichtman, 2014) about how students with

ADHD learn by applying PRV and SCV by determining the students' and teachers' views. In designing the semi-structured interviews, the following issues guided this process, and a special format (simple and understandable questions, awareness of the child's attention, etc.) was necessary, as some participants were children. Cohen et al. (2011) suggested that choosing a suitable language (for example, considering the children's age, ensuring clarity) and considering the time for thinking and responding are important aspects to consider. The researcher, as the interviewer, used a list of interview questions (20. Children's Post-test Interview Questions and 26. Teachers' Interview Questions in Appendix 1) provided clarification, as needed, and devised a guide for the interview (the time for every question to control the length of the interview, the sequence of the questions and the instructions depending on the response) because some of the interviewees were children.

Despite the advantages of interviews, as previously mentioned, there are some limitations that should be addressed. For example, interviews can be time-consuming (Cohen et al., 2011). As some interviewees in this study were children, the time for answering or thinking before every question will not be the same as for teachers. In addition, each interview lasted at least 20 minutes, but as some interviewees were children with ADHD, their interactions and reactions with interview questions were not predictable; thus, it was expected that interviews would take longer. Interviews have a high possibility of introducing biases through their use of leading questions (Zohrabi, 2013); thus, the current research tried to avoid using such questions. Finally, some people may refuse to be interviewed or become uncomfortable during the interview (Kumar, 1999; Cohen et al., 2011; Zohrabi, 2013). Thus, the consent of the participating children was obtained, and it was made clear to them that they were free to withdraw from the study at any time.

3.4.2.2.2 The Semi-structured Interview Data Collection

The quantitative analysis provided an overview of the numerical data related to the impact of using SCV and PRV on ADHD students' ability to solve mathematical word problems, as highlighted in Chapter 4. However, the quantitative phase analysis could not capture how using SCV and PRV can build meaning or in-depth understanding in terms of the extent to which SCV and PRV helped the ADHD students solve mathematical word problems. Therefore, the quantitative phase analysis was complemented by a qualitative analysis looking deeply and specifically at how ADHD students benefit from using SCV and PRV.

While data were collected from 20 students to address the first and second research questions, only 16 students took part in the interviews to address the third research question. Four students decided not to participate in the interview and withdrew. In addition, 10 teachers participated in the interviews and were interviewed about the 20 students with ADHD who participated in the current study. All participating teachers were females in their 30s. Pseudonyms were used to ensure participants' confidentiality, as previously discussed. Similar pseudonyms were used for teachers; for example, 6-B-SCV indicated the sixth teacher in the boys' school who was interviewed in SCV.

Each student and teacher were interviewed independently for approximately 15-20 minutes, using a semi-structured interview; thus, the answers of one student or one teacher were not influenced by another student or teacher. The interviews were audio recorded for the purposes of transcription, translation, and analysis during the subsequent stage. The interviews were held in the students' schools and were conducted after the intervention phase was completed (in the beginning of November 2019 for the girls and in the beginning of December 2019 for the boys).

This interview stage took two weeks to complete: one week in the girls' school and one week in the boys' schools. The interviews were scheduled by the head teachers in each school, depending on students' availability. At the beginning of each interview, students were notified that they would be asked questions about using SCV and PRV to solve mathematical word problems. In addition, to collect more information about SCV and PRV, students were asked to solve one mathematical word problem at the beginning of the interview. The question was very basic in nature: "One taxi can load four passengers. How many passengers can six taxis load?" A similar procedure was followed for teachers' interviews, except for the word problem in the beginning of the interview.

It was important for this study to give students the opportunity to speak for themselves and provide perceptions of the advantages and disadvantages of SCV and PRV. However, as children's capacity to express their opinions is limited in terms of their cognitive and communicative ability (Nilsson et al., 2015), the concept of "ADHD behaviour" might not be as clear as the concept of "mathematical word problem-solving ability". Therefore, there were no interview questions about the impact, if any, of the intervention on students' ADHD behaviour. In addition, the researcher believed that asking ADHD students about their behaviour could be quite a sensitive matter for students to talk about. Instead, the perceptions of the potential impact of SCV and PRV on ADHD students' behaviour were collected only from the students' teachers, which are discussed in Chapter 7.

3.4.2.2.3 Translation Procedure

The translation procedure was divided into two translation mechanisms to ensure the validity, reliability, and translation quality of the interview transcripts. The first mechanism was parallel translation (PT), which is where translation quality was measured using a human reference translation to compare the similarity between the two translations (Hassan et al., 2018; see Figure 3.1), which could also be referred to as sentence pair comparisons or the number of sentence pairs (Ramesh & Sankaranarayanan, 2018). The second mechanism was back-translation (BT), which helped develop user assurance of the translation by questioning the translation from the target language to the translated language (Elayeb, Romdhane, & Saoud, 2018). Both translation mechanisms are detailed in Figures 3.1 and 3.2.

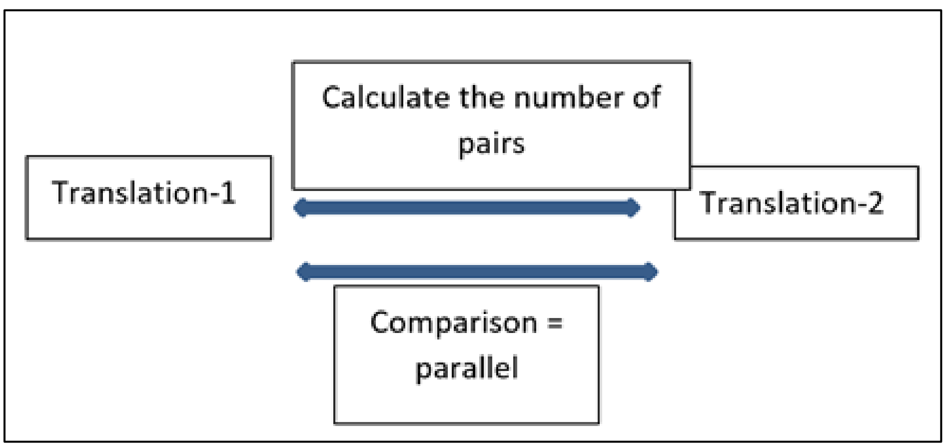


Figure 3.1 Translation mechanism

The original instrument (interviews) was conducted in Arabic. The transcript was first translated into English. A parallel translation (PT) was used with an English language professional. A parallel translation was used to enhance the similarity of each word with its context in the English language (Johnson, Firat, Kazawa, & Macherey, 2018). The main advantage of using PT is that it helps achieve the pattern of meaning or the semantic pattern of the translation (Malá & Brůhová, 2018).

This translation mechanism started by having the same interview transcripts for both the researcher and the English language professional, who then compared both translations to determine if both were similar. If both translations were parallel, the translation was adopted. If the translations were not parallel, they looked for the reason behind the differences in the two translations and then corrected it until they achieved similarity in wording and meaning. This translation mechanism has disadvantages; for example, Ramesh and Sankaranarayanan (2018) reported that this type of translation can have a low translation accuracy, resulting in an inaccurate translation. To avoid the disadvantage of the parallel translation, a back-translation was also used, as discussed next.

Back-translation is a mechanism used to translate the monolingual data (for example, interviews transcribed into English) into the source language (i.e. Kuwaiti Arabic); the result should be parallel (Edunov, Ott, Auli, & Grangier, 2018; see Figure 3.2). The main advantage of using BT is to ensure the accuracy of the translation before the analysis (Edunov et al., 2018). The BT for this study's interview transcripts was done in three steps. The first step was to have the interviews transcribed in the original language—in the case of this study, Kuwaiti Arabic. The second step was to translate the original interview transcripts into English. The final step was to find a speaker of the original language to translate it from the English translation back into Kuwaiti Arabic once again. This final document should be similar to the original document. BT was used with only 50% of interview transcriptions from English to Arabic.

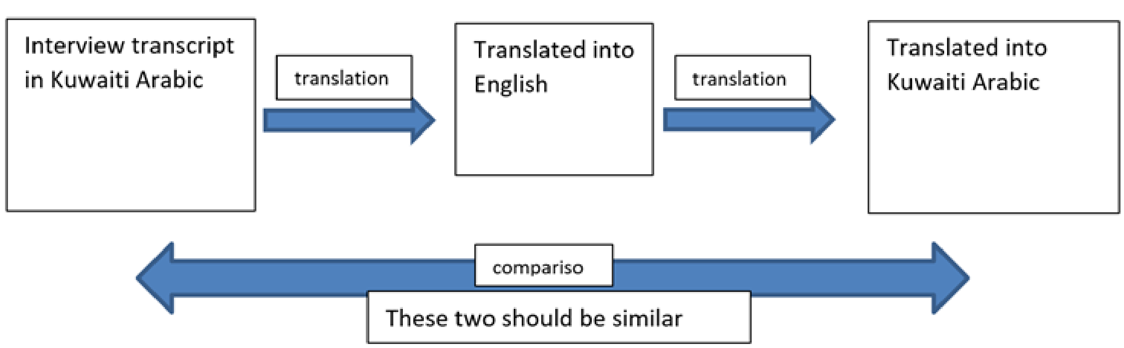


Figure 3.2 Back translation

3.5 Sampling and Sampling Criteria

Sampling refers to the process of choosing participants as a source for the outcomes or data (Cohen et al., 2011; Creswell, 2014; Edmonds & Kennedy, 2017). The appropriateness of the sampling is important for increasing the research quality (Cohen et al., 2011). There are two sampling strategies: probability and non-probability (Cohen et al., 2011; Edmonds & Kennedy, 2017). For the current study, different sampling techniques were used at different stages of the research. For example, choosing the schools and ADHD can be described as purposive sampling (one type of non-probability). Otherwise, within the schools, children were chosen using simple random sampling (one type of probability) for the experimental design.

Non-probability sampling is broadly divided into two types: convenience sampling and purposive sampling (Edmonds & Kennedy, 2017). Convenience sampling refers to a sampling strategy in which the participants are selected because of their convenient accessibility to the researcher (Thomas, 2013), but it has many limitations, including a high risk of selection bias and uncontrolled influences (Edmonds & Kennedy, 2017). Purposive sampling is defined as a sampling strategy that involves selecting the participants for the purpose of the research (Cohen et al., 2011). It was used for this study, as explained below.

3.5.1 Selection of Two Schools and Participants

The two schools for students with learning disabilities selected for this study cater to all children diagnosed with ADHD in government schools anywhere in Kuwait. All the children with ADHD who are 9 to 11 years old in the two schools were approached to participate in the study because this population is so small. As the aim of this research is to study such children, the sample was a purposive one because it only focused on ADHD children. The sample included a minimum of three boys and three girls who are all 9-11 years old and have been diagnosed with ADHD. An incidental advantage is that the researcher happened to teach in one of the schools, which made it easier for her to enter these schools and conduct the study.

3.5.2 Sample Size

Sample size refers to the number of participants included in the study (Kumar, 1999; Cohen et al., 2011). This aspect of research can be problematic for any researcher because there is no straightforward answer to the sample size issue; rather, the sample size depends on the purpose of the study (Cohen et al., 2011; Lichtman, 2014). For this study, the sample size for both the quantitative method (experiment) and the qualitative method (interviews) was necessarily small (the same 6+ children; see the previous section) because the participants were ADHD students who can be considered as small populations in any school. One limitation of such a small sample is that the findings cannot be generalised and may be very untypical of students with ADHD. The experimental phase involved a sample size of 20 ADHD students (8 girls, 12 boys), aged 9-11 years. Thus, a total of 20 students with ADHD participated, 10 in the intervention group and 10 in the comparison group. However, as some students did not wish to be interviewed, the sample size for the interviews was 15 ADHD students (8 girls, 7 boys). Finally, 10 teachers were interviewed.

3.6 Data Analysis

3.6.1 Quantitative Data Analysis

The quantitative methods, such as the experiment, observation, and surveys, all aimed to compare two situations—namely, SCV and PRV students' mathematical word problem-solving ability when using SCV or PRV. In addition, the observations compared changes in ADHD behaviours among students in the SCV and PRV groups during the 20 sessions. Similarly, the surveys compared the teachers' perceptions of SCV and PRV students' mathematical word problem-solving ability and behaviours, before and after applying the intervention. A *t*-test served as a more suitable test to analyse the data in the quantitative methods except for the observations, where a regression test was used to understand the differences between students in the SCV and PRV groups by comparing the regression coefficient. Furthermore, to understand the relationship between the use of SCV and students' test results (pre-test, post-test, and delayed post-test), a correlation test was used. In addition, the surveys' reliability was determined using Cronbach's alpha.

3.6.1.1 Independent Sample t-Test

A *t*-test is used to compare the mean scores of two different independent groups (Pallant, 2016). The comparison was constructed between the research variables in the SCV and PRV models using the *t*-test. The *t*-test for the SCV and PRV variables was constructed to determine if a significant difference occurred in the research variables between the SCV and PRV groups and if any improvement in solving mathematical word problems emerged due to the application intervention.

The null hypothesis for the independent samples *t*-test is that the population means from the two unrelated groups are equal (Field, 2018):

H0: u1 = u2

Thus, the data from the pre-test, post-test, and delayed post-test for the SCV and PRV groups were equal.

An independent samples *t*-test can also reject the null hypothesis and accept the alternative hypothesis, which is that the population means are not equal (Field, 2018):

HA: u1 ≠ u2

which, in this case, means the data from the pre-test, post-test, and delayed post-test for the SCV and PRV groups were not equal. According to Larson-Hall (2015), the significance level (also called alpha) allows us to either reject or accept the alternative hypothesis. Most commonly, this value is set at 0.05. The construct examined both groups (SCV and PRV) in the pre-test, post-test, and delayed post-test. As the *t*-test is a parametric test, the normality hypothesis was tested to apply a parametric test.

3.6.1.2 Paired Samples t-Test

The paired samples *t*-test compares the means between two related groups on the same continuous dependent variable (Field, 2018). A paired sample *t*-test was used to understand whether differences in abilities to solve mathematical word problems existed within the same groups (SCV or PRV). Thus, the dependent variable was the mathematical word problem-solving ability, and the tests were the pre-test, post-test, and delayed post-test. The objective of using the paired samples *t*-test was to understand the impact of the experiment instrument (pre-test, post-test, and delayed post-test) within the same group.

The paired samples *t*-test's null hypothesis was that no significant differences existed among the means of two related groups (Pallant, 2016):

H0: $\mu 1 = \mu 2$

This means that, for example, if the pairing was between the pre-test and post-test for the participant using PRV, and the paired samples *t*-test was not significant, the null hypothesis was confirmed. According to Pallant (2016), getting a significant result rejects the null hypothesis of the paired sample *t*-test:

HA: $\mu 1 \neq \mu 2$

For example, if the pairing was between the post-test and delayed post-test for participants using SCV and the result was significant, it would indicate a significant difference between both conditions.

3.6.1.3 Regression Test

The objective of using a linear regression test is to understand if students' ADHD behaviours changed in each group (i.e. SCV and PRV) during the 20 sessions. Additionally, a regression test can help measure the continuous variable for the dependent variable (Pallant, 2016). In the current study, a regression test helped to understand how ADHD behaviour changed over 20 sessions. Therefore, as the same observation was conducted repeatedly over the 20 daily sessions for each student, it helped ascertain whether behaviour had decreased, using the regression line during the 20 sessions (for more details of the regression line, see Chapter 5).

Furthermore, Jorgensen (2019) clarified that linear regression is appropriate for understanding the different conditions of an experiment involving two variables. In the current study, the experiment conditions were ADHD inattention behaviour and hyperactivity/impulsivity, which were measured according to the rate at which the behaviours appeared (see Chapter 5); the two variables were the groups and the number of sessions. As Jorgensen (2019) discussed, the relationship between the experiment variables should be approximately linear, as shown in the regression line figures for ADHD behaviours in Chapter 5.

The dependent variable is the ADHD behaviours while the independent variables are the groups (i.e. SCV and PRV) and the number of sessions (20 sessions). To understand if the relationship between the dependent and independent variables is linear, a scatterplot was done for each of the elements of ADHD behaviours, as shown in Chapter 5. The scatterplot showed a downward linear relationship for each element of ADHD behaviour, indicating that the ADHD behaviours of students in SCV and PRV decreased.

Jorgensen (2019) argued that testing the regression assumptions before starting the analysis is important. These assumptions are:

1. Linearity,
2. The variables are independent,
3. Homogeneity, and
4. Normality.

These assumptions were tested (see Chapter 5 for the normality for the observation).

However, Field (2018) included an additional regression assumption, which is the Durbin-Watson test, to ensure that the data are correct and ready to be tested using a regression test. The Durbin-Watson test allows for testing a serial correlation (autocorrelation) in residuals (i.e. the line of best fit in the linear regression) for regressions (Durbin & Watson, 1950; Turner, 2019). Thus, this type of test shows how the data of the observation are correlated and fit the regression test. Furthermore, this test helps investigate the distribution (Yin, 2020). For more details about the testing the regression test assumptions see Chapter 5.

3.6.1.4 Correlation Test

Correlation can be defined as a way of measuring the extent to which two variables are related and associated (Field, 2018). The objective of measuring the correlation is to understand the relationship between using the SCV and the students' score in each test (pre-test, post-test, and delayed post-test). Before applying the correlation test, four assumptions should be met (Field, 2018). These assumptions help decide which correlation test should be used.

According to Pallant (2016), if the assumptions are met, Pearson's correlation coefficient will be used; if not, Spearman's correlation coefficient will be used. The first assumption is that the two variables should be measured at the interval or ratio level, as the current study used test score measured from 0 to 6 and the frequency of using SCV was measured as a score from 0 to 6; this assumption was met. The second assumption is linearity, where there should be a linear relationship between the two variables (test scores and the frequency of using SCV). Using scatterplot by SPSS is one way of testing linearity (see Chapter 4). The third assumption is that there should be no significant outliers. The outliers can be defined as single data points within the data that do not follow the usual pattern (see Chapter 4). Shapiro-Wilk was used to test if the data were normally distributed or not (for more clarification, see Chapter 4).

3.6.2 Qualitative Data Analysis

To analyse data relating to the third and fourth research questions, a constant comparative analysis was used to analyse the interview data. Constant comparative analysis refers to a technique that allows data to emerge by using an inductive process (coding the information) to reduce the data (Fram, 2013; Ragin, 2013; Simon & Hadrys, 2013). The coding process started with open codes to develop categories which allow the core code to emerge (Fram, 2013). This study followed Guba and Lincoln's (1994) three steps in applying constant comparative analysis: it started with a comparative coding process in which each event had its own codes and each code was divided into categories. The next step was comparing incidents of each category, which helped understand the differences and similarities of the categories so that the categories can be integrated. The final step was writing the theory, which in the context of this study, involved generating a theoretical understanding of the students' perceptions of the effect of using PRV and SCV on students with ADHD.

3.6.2.1 Transcript Analysis

At this point, a detailed examination of the qualitative data (interview data) was needed to answer the third and fourth research question. In addition, by analysing the interview transcripts, the researcher could use the richly generated data to provide an understanding of and explore teachers' perceptions of using both visualisation tools in SCV and PRV to solve mathematical word problems and affect ADHD behaviour. Furthermore, analysing the transcripts helped determine the balance of talk and the richness of details as well as which points were raised.

To analyse the interview transcripts, a constant comparative analysis (CCA) was used. A CCA is a purely inductive grounded method (Waters, 2018; Whalen, Goldstein, Urquhart, & Carter, 2018) and a systematic approach for understanding the interpretation of the interview transcripts to explore the process and how the process was effective (Waters, 2018; Whalen et al., 2018). The process in this study used SCV or PRV with ADHD students, and this type of analysis allowed for a comparison of the tools to determine which was more effective with students with ADHD in mathematical performance when solving mathematical word problems. The participants' experiences were the core of the analysis.

The CCA process started after transcribing the interviews (qualitative data), which included developing the themes and subthemes (Richards & Hemphill, 2018) to summarize the interview transcripts. To establish themes, a coding framework was used to categorise the data (Whalen et al., 2018). According to Whalen et al. (2018), a coding framework works by having a core code for the interview transcripts occurring concurrently. The core code helps develop the categories and integrate them into main themes (Whalen et al., 2018). To analyse the study interview transcripts, Richards and Hemphill's (2018) analysis steps were followed: (a) preliminary organisation and planning, (b) open and axial coding, (c) development of a preliminary codebook, (d) pilot testing the codebook, (e) final coding process, and (f) review of the codebook and finalising the themes.

Every line of the interview transcripts was coded for emerging ideas. Using the CCA allowed the researcher to move back and forth from the code to the emerging data or patterns to identify any similarities or differences when developing the code structure to accommodate new ideas. All of these steps helped limit the possibility of preconceived results.

3.6.2.2 Generating Codes and Themes

After the interview data were prepared and managed through transcription and translation, as discussed thus far, the qualitative analysis was carried out by generating codes and themes. According to Creswell and Poth (2017), presenting qualitative data is a challenging process, especially in terms of which way should be followed to present the data. There are several perspective and guidelines for analysing the qualitative data. For example, Creswell and Poth (2017) stated that “Madison (2005) presents a perspective taken from critical ethnography, Huberman and Miles (1994) adopt the systemic approach to analyse, and Wolcott (1994) uses a more traditional approach to research from ethnography and case study analysis” (p.148). Based on Creswell and Poth’s (2017) discussion, the approach by Huberman and Miles (1994) is appropriate for the current study because it provides details about writing the notes and field notes and identifying the relationship among the themes or the categories (Creswell & Poth, 2017).

After taking notes from all the interview transcripts by scanning all the databases and generating more details about the data, the next step was to generate general codes and themes, a method called inductive analysis (Creswell & Guetterman, 2018). According to Creswell and Poth (2017), and Creswell and Guetterman (2018), coding involves moving from taking notes and memories to labelling, classifying, and interpreting the transcript data.

After the interview data were prepared through transcription and translation, the qualitative analysis was carried out by generating codes and themes (Creswell & Poth, 2017). The data were analysed with a constant comparative analysis approach, which is considered to be inductive analysis (Creswell & Guetterman, 2018), according to the following steps:

- Fixing the codes from the notes taken.

- Scanning the transcripts for more remarkable phrases.
- Continuing to scan for more relationships or patterns between the interview transcripts.
- Isolating the patterns according to the communalities and differences.
- Combining patterns with similar meanings together in small sets to show the consistency of the data.

In addition, Miles, Huberman, and Saldaña's (2014) analysis approach helped develop the codes first and then the themes, meaning the analysis followed a bottom-up approach. The process of looking at the transcript repeatedly for more emerging themes or codes does not stop because the current study used constant comparative analysis based on an inductive analysis (Creswell & Guetterman, 2018).

3.7 Validity and Reliability

3.7.1 Quantitative Research

Validity in the context of quantitative research can be defined as having true and realistic data through the use of positivist paradigms and values (Cohen et al., 2011). Positivist values refer to the term "faithful premises", which includes assumptions, instrumentations, statistical data, and content (Cohen et al., 2011). There are three types of validity in the context of quantitative research: external validity, which refers to the ability to generalise and secure the results with a random sampling size technique for the relevant population (Creswell & Plano Clark, 2011); construct validity, which refers to the ability to measure the constructed promises through the study (Edmonds & Kennedy, 2017); and internal validity, which measures whether the research has been done properly and correctly (Devellis, 2016; Hair, Black, Babin, & Anderson, 2010).

As this research was not concerned about generalising the results, external validity was not be considered further. In contrast, construct validity can provide a clear picture about the results by underscoring the relationship between different variables (Oppenheim, 2009; Creswell & Plano Clark, 2011; Thomas, 2013) and providing insights about the constructed knowledge when using RSV and SCV. This type of validity was considered for this research, as it could help determine how using PRV and SCV affects mathematical ability in solving word problems and changing ADHD behaviour. To measure construct validity for the current study, a pre-test and post-test was applied to measure whether significant differences existed in mathematical ability by using PRV and SCV. Internal validity was also considered in this research, as it helps experimental research by highlighting the confounding variables (Creswell & Plano Clark, 2011; Edmonds & Kennedy, 2017). Confounding variables are variables which can occur within the study; they can cause biases and increase variance (Glen, 2017). For example, in this research confounding variables can be the individual differences in mathematical abilities, skills in drawing, and age. In the current study, the risk of confounding variables affecting the results was minimised, in that the allocation of the children, using SCV and PRV, and length of time was controlled, as shown in Table 3.1.

In quantitative research, reliability is defined as reapplying the same scale or test on the same sample during a relatively short period and yielding the same result each time (Oppenheim, 2009; Thomas, 2013); other researchers refer to reliability as stability (for example, Cohen et al., 2011; Bowling, 2014). In the context of this study, a high value would indicate very similar results between the original experiment and a later duplication of it. Equivalent forms of reliability measure the ability to obtain the same results by using equivalent tests or procedures (Cohen et al., 2011; Bowling, 2014). Regarding the reliability of this study, the question is whether the same results would be obtained if the same study is repeated for the same sample. This cannot be achieved because the students gained the experience of using visualisation to learn mathematical word problems by the end of the study; thus, the results did not match and might not be reliable.

3.7.2 Qualitative Research

Validity in the context of qualitative research refers to the truthfulness that may emerge within information collected from the interpretive approach (Creswell & Plano Clark, 2011). According to Cohen et al. (2011) and Edmonds and Kennedy (2017), it is important to have a quality measurement for the research, especially for interpretive data, which is dependent on participants' views or opinions; these views or opinions can change over time. Therefore, the validity of the qualitative methods used in the current research refers to students' and teachers' experiences regarding their honesty through their interpretations. It is difficult to measure validity; however, some strategies can be used to increase the validity of the qualitative research methods.

Three strategies have been identified for establishing validity in the context of qualitative research: well-known approach, triangulation, and dependability and credibility (Creswell, 2009; Creswell & Plano Clark, 2011; Flick, 2014). Using the well-known approach, findings were summarised, and participants were asked whether the findings are accurate (Creswell, 2009; Creswell & Plano Clark, 2011; Flick, 2014). The triangulation approach draws data from numerous individuals, and it can be easier than other approaches for the validation of data (Cohen et al., 2011; Flick, 2014). In addition, triangulation can occur in the form of the methods of data collection, such as the use of the intervention experimental design, observations, surveys and semi-structured interviews in the context of the current study. This helped the current study find a balance between the weaknesses and strengths of the methods.

Finally, dependability and credibility were established by reviewing and examining the research process (Creswell, 2009). Dependability is defined as the process responsible for the logical, traceable, and documentable of the inquiry (Schwandt, 2015). Credibility refers to the ability to find homogeneity between the researcher's interpretation and participants' expressions through the methodological processes (Given, 2008). In order to achieve dependability and credibility, Given (2008) suggested three strategies that can be followed: refining the coherence in the methodological process (collecting the analysis and interpretation of the data); building an understanding of the data through verifications of the finding (for example, by using a different type of mathematical word problem in a future study) and analysing the participants' expressions; and examining detailed transactions of all the procedures and issues related to the research process. This helped the current study understand how research methods are interrelated, which is reflected in the understanding of the results and their interdependence.

Reliability in qualitative research is an issue because, in interpretative research, multiple realities (for example, participants' views) are entirely possible and can potentially change from time to time (Thomas, 2013). Thomas (2013) argued that reliability is "in my opinion, irrelevant in interpretative research" (p.139) because in qualitative (interpretative) research, perceptions can be changed if they are repeated. The current study sought to ensure that the reality of the researcher's interpretation of the data and the findings was consistent with the reality collected from the participants by following the standard of dependability and credibility discussed herein. Moreover, the reliability of the interview can be assessed by the quality of the recorded data (Creswell, 2009). Thus, all the interview transcripts were recorded using a voice recorder. In addition, written transcripts of the interviews were made in Arabic (the participants' first language). The transcripts were translated from Arabic to English by the researcher, and then another translator checked the accuracy of the translation. This process increased the reliability of the data and findings.

3.8 Ethical Considerations

Ethics is concerned with evaluating how humans are employed in research, such as whether they are at risk of being harmed in any way (Coe, Waring, Hedges, & Arthur, 2017). Ethical considerations are a critical issue that should be considered for any study (Kumar, 1999; Cohen et al., 2011). Ethical guidelines must be followed to ensure no harm will be caused to the participants, either during or after the study. This includes respecting the information acquired from the participants, being honest about the nature of the study with the students and their parents and avoiding any possible harm to both the researcher and participants (Cohen et al., 2011; Robson & McCartan, 2016). In addition, ethics are important for the research quality for avoiding biases, reporting accurate information, and using acceptable methodology (Cohen et al., 2011). Arguably, ethics can be more complicated when using qualitative methods than when using quantitative methods because the qualitative methods are based on personal interactions and are interpretive (Mertens, 2014). Thus, it depends on how the researchers transcribe the interpretations of the participants.

Upholding ethics in research and practice requires the study to follow the code for professional practice (Cohen et al., 2011), specifically the University of Reading’s Code of Good Practice in Research (UKRIO Code) and the code of the British Educational Research Association (BERA, 2011) to ensure that the research undertaken remained within the law and adhered to clear ethical guidelines. The ethical issues were considered very carefully during the study. The participants’ confidentiality and anonymity were protected from any harm.

Permission to conduct the study was obtained from the Ethics Committee of the University of Reading's Institute of Education and the Ministry of Education in Kuwait. As this research was conducted with children, information sheets and consent forms were delivered to the parents and head teachers of both schools (Cohen et al., 2011; Robson & McCartan, 2016). Moreover, the use of the consent form was a critical feature of the research ethics, as the participants in this study were children in schools; therefore, four consent forms were created (for the school's head teachers, for the parents, and for the students to participate), with a written guarantee of confidentiality and anonymity. The research supervisors and the researcher are the only people who can access the recorded data from the experiment, observations, and interviews, and these records were kept in a safe place until the research concluded. To ensure each participant's comfort and safety, they had the right to withdraw at any stage, and the entire research process was conducted in the school environment.

3.9 Summary

This chapter has provided an overview of, and explanations for, the methodology used in the current study. It has described the research paradigm and the philosophical assumptions for building the current research paradigm (pragmatism). An explanatory mixed methods design was employed by using both the quantitative approach (experiment and structured observation) and qualitative approach (semi-structured interviews). Each method has been discussed in terms of the data collection and analysis, along with issues of reliability and validity. The sampling strategy and ethical considerations have also been presented.

CHAPTER 4: ANALYSIS AND FINDINGS FOR RESEARCH QUESTION ONE

4.1 Introduction

This chapter provides an overview of the analysis and findings of the experiment used to answer the first research question *(To what extent do PRV and SCV help students with ADHD to solve mathematical word problems?)*. A summary of the experiment and its data-gathering strategies is followed by a discussion of how the findings from the quantitative analysis, along with the information previously gathered from the literature review, were used to develop the intervention instrument (i.e. SCV). The chapter then presents how the *t*-test (independent and paired samples) analysis was performed on the intervention data to identify the impact of SCV (the intervention group) compared to PRV (the comparison group) on the mathematical word problem-solving ability of students with ADHD.

4.2 Statistical Analysis and Its Assumptions

After collecting all the experimental data, the data were entered into SPSS (Version 25) to perform descriptive statistical analyses, and further statistical analyses (*t*-test) were used to compare the results from the intervention group (SCV) and the comparison group (PRV). The statistical tool *t*-test by SPSS was used to test the proposed hypotheses:

> H0: There are no significant differences between students with ADHD in the intervention group (SCV) and comparison group (PRV) in terms of mathematical abilities to solve mathematical word problems.

H1: There are significant differences between students with ADHD in the intervention group (SCV) and comparison group (PRV), in terms of mathematical abilities to solve mathematical word problems.

Before testing these hypotheses, exploring the distribution was necessary to see whether or not to use the parametric test as below.

4.2.1 Testing Normality for the experiment

Field (2018) indicated that, before choosing a test to analyse quantitative data, exploring the distribution is necessary. Pallant (2016) and Field (2018) emphasised that exploring the distribution to see whether or not to use the parametric test could be done by testing the distribution hypothesis or assumptions (i.e. normality, homoscedasticity and linearity).

Although some researchers, such as Larson-Hall (2015), have argued that parametric tests are robust even if these assumptions are violated, Field (2018) argued that using a parametric test when the assumptions are not met could increase the possibility of a Type 2 error (i.e. not finding a relationship between variables when, in fact, one exists). In the case of the distribution assumptions being violated, a non-parametric test (distribution-free test) could be used, although sometimes non-parametric tests can be considered as less powerful than the parametric ones because their influence of the outliers relies on using the median rather than mean (Field, 2018). In fact, they can be very powerful in finding statistical differences between the variances (Larson-Hall, 2015). Therefore, an investigation as to whether the distribution of the data collected meet or violate these assumptions is important and will be discussed in the following sections.

In the context of this study, normality means that the dependent variable was approximately normally distributed within each group (i.e. SCV and PRV). An assessment of the normality of data is a prerequisite for many statistical tests because normal data are an underlying assumption in parametric testing (Field, 2018). There are two main methods for assessing normality: graphically and numerically. In the current study, only the numerical method was used (for example, the Shapiro-Wilk test, skewness test, kurtosis test). As the skewness and kurtosis tests can give an indication about the graphic test, a histogram was not necessary to interpret the experimental tests.

4.2.1.1 Shapiro-Wilk Test

Table 4.1 indicates that the Shapiro-Wilk test was used to identify a significant value. If the result is greater than 0.05, the data are taken to be normally distributed; if the result is less than 0.05, the data significantly differ from a normal distribution (Field, 2018). The Shapiro-Wilk test was used instead of the Kolmogorov-Smirnov test for normality because the former is more appropriate for small sample sizes (Field, 2018), making it appropriate for this study with only 20 participants.

Table 4.1 indicates that, in the pre-test, neither the SCV nor PRV groups were normally distributed, because students in both groups had similar test results. Additionally, in Test 4, the post-test, and the delayed post-test for the PRV group, the results were not normally distributed, which could suggest the participants were not interested in completing the task or failed to solve the task, resulting in almost similar grades. Table 4.1 also indicates that six of the 14 results from the Shapiro-Wilk normality test were not normally distributed. As the number of results that differed on the normality test was small, normality was assumed for the study's data.

Table 4.1 Shapiro-Wilk Test for Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Group C	Statistic	df	Sig.	Statistic	df	Sig.
Pre-test	PRV	.362	10	.001	.717	10	**.001**
	SCV	.272	10	.035	.802	10	**.015**
Test 1	PRV	.200	10	.200*	.953	10	**.709**
	SCV	.181	10	.200*	.895	10	**.191**
Test 2	PRV	.188	10	.200*	.911	10	**.288**
	SCV	.247	10	.084	.910	10	**.283**
Test 3	PRV	.219	10	.191	.843	10	**.048**
	SCV	.155	10	.200*	.969	10	**.886**
Test 4	PRV	.245	10	.091	.820	10	**.025**
	SCV	.181	10	.200*	.950	10	**.668**
Post-test	PRV	.231	10	.139	.824	10	**.028**
	SCV	.217	10	.200*	.896	10	**.198**
Delayed post-test	PRV	.236	10	.123	.841	10	**.046**
	SCV	.160	10	.200*	.942	10	**.575**

4.2.1.2 Skewness and Kurtosis Tests

According to Field (2018), to get an approximately normal distribution, both skewness and kurtosis should have a value of zero or near zero (between 0.05 and 1). A positive skewness score means the distribution builds low whereas a negative score means the distribution builds high; a positive Kurtosis score means the tail of the distribution is heavy whereas a negative score means the tail is light (Field, 2018). Table 4.2 highlights both negative and positive skewness and kurtosis scores, although most of the results are near zero. However, Table 4.2 indicates two high kurtosis scores: on Test 2 and the delayed post-test, both of which have a negative sign. This result suggests that the normality did not materialize for these two tests, which could be due to students' behaviour on that day or their motivation to solve the test one month after the intervention (i.e. delayed test). As only two results did not conform with the normality tests of skewness and kurtosis, which can be affected by students' mood or behaviour, the researcher decided that normality was achieved.

Table 4.2 Skewness and Kurtosis Tests for Normality

	N	Minimum	Maximum	Mean		Std. Deviation	Skewness	Kurtosis
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic
Pre-test	20	0	2	0.65	0.167	0.745	0.697	-0.762
Test 1	20	0	5	2.30	0.291	1.302	0.331	-0.484
Test 2	20	1	6	3.45	0.380	1.701	-0.083	**-1.017**
Test 3	20	1	6	3.40	0.311	1.392	0.359	-0.503
Test 4	20	1	6	3.50	0.276	1.235	0.000	-0.152
Post-test	20	0	5	2.65	0.293	1.309	-0.208	-0.595
Delayed post-test	20	0	4	1.50	0.286	1.277	0.253	**-1.090**

4.2.1.3 Linearity

Linearity means that the predictor variables in the regression have a straight-line relationship with the outcome variable (Field, 2018). In other words, "the relationship between two variables should be linear" (Pallant, 2016, p.130). The researcher checked the linearity by using the linear regression test in SPSS. Therefore, the relationship between the error in the experiment and the predicted results from the experiment will be clear. The P-P scatterplot compares the distribution of the residuals with a normal distribution (a theoretical distribution which follows a bell curve). In the P-P scatterplot, the solid line represents the theoretical quantiles of a normal distribution. Normality can be assumed if the points form a relatively straight line. Figure 4.1 shows that all the graph points are linear and did not have a curved shape.

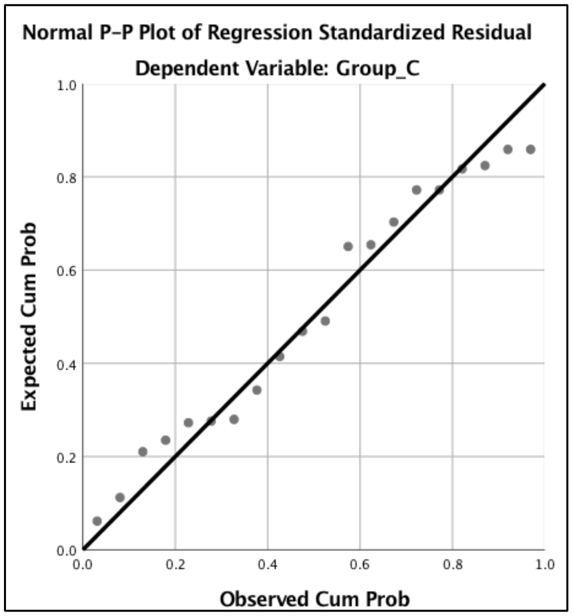


Figure 4.1 Linearity test

4.2.1.4 Homoscedasticity

Homoscedasticity refers to the equality of variances or the homogeneity of variances (Pallant, 2016; Field, 2018). The current study assumed that the variances were equal across both groups (SCV and PRV) for each test. To verify this assumption, the Levene test was used. The Levene test assumes that "the variances for different groups are equal" (Field, 2018, p.257) and valid (Leven test null hypothesis); if this assumption is valid, then the distribution is confirmed. If the significance of Levene's test is under 0.05, the equal variances assumption is violated (Field, 2018).

According to Field (2018), the Levene test can be done by using one-way ANOVA in SPSS (see Table 4.3). This study used the significance of the mean because using the mean showed a moderately tailed distribution, where the trimmed mean was being used for the heavy tailed distribution (Field, 2018). Table 4.3 demonstrates that the Levene test shows $p > 0.05$. Therefore, the null hypothesis of the Levene test was confirmed, and the variance in different groups (SCV and PRV) for each test could be assumed as equal. Table 4.3 shows that, for the pre-test, F(1,18) = 1.057, *p* = .318; the post-test result was F(1,18) = .163, *p* = .691. Finally, the Levene test result for the delayed post-test was F(1,18) = .000, *p* = 1.000.

Table 4.3 Test of homogeneity of variances

		Levene Statistic	df1	df2	Sig.
Pre-test	Based on mean	**1.057**	1	18	**.318**
	Based on median	.101	1	18	.754
	Based on median and with adjusted df	.101	1	15.100	.755
	Based on trimmed mean	.830	1	18	.374
Post-test	Based on mean	**.163**	1	18	**.691**
	Based on median	.060	1	18	.809
	Based on median and with adjusted df	.060	1	17.902	.809
	Based on trimmed mean	.209	1	18	.653
Delayed post-test	Based on mean	**.000**	1	18	**1.000**
	Based on median	.000	1	18	1.000
	Based on median and with adjusted df	.000	1	17.308	1.000
	Based on trimmed mean	.001	1	18	.970

4.2.2 The t-Test

4.2.2.1 Independent Samples t-Test

A *t*-test is used to compare the mean scores of two different independent groups (Pallant, 2016). The comparison was constructed between the research variables in the SCV and PRV models using the *t*-test. The *t*-test for the SCV and PRV variables was constructed to determine if a significant difference occurred in the research variables between the SCV and PRV groups and if any improvement in solving mathematical word problems emerged due to the application intervention. The null hypothesis for the independent samples *t*-test is that the population means from the two unrelated groups are equal (Field, 2018):

$H_0: u_1 = u_2$

Thus, the data from the pre-test, Test 1, Test 2, Test 3, Test 4, post-test, and delayed post-test for the SCV and PRV groups are equal.

An independent samples *t*-test can also reject the null hypothesis and accept the alternative hypothesis, which is that the population means are not equal (Field, 2018):

$H_A: u_1 \neq u_2$

which, in this case, means the data from the pre-test, Test 1, Test 2, Test 3, Test 4, post-test, and delayed post-test for the SCV and PRV groups are not equal. According to Larson-Hall (2015), the significance level (also called alpha) allows us to either reject or accept the alternative hypothesis. Most commonly, this value is set at 0.05. The construct examined between both groups (SCV and PRV) in the pre-test, Test 1, Test 2, Test 3, Test 4, post-test, and delayed post-test. As the *t*-test is a parametric test, the normality hypothesis is tested to apply a parametric test.

4.2.2.1.1 Independent Samples t-Test Findings

Descriptive statistics are used to describe or summarize the data. Table 4.4 shows the results of descriptive statistics corresponding to test variables (i.e. pre-test, Test 1, Test 2, Test 3, Test 4, post-test, and delayed post-test). It can be seen from the result obtained that the students had the highest mean score in Test 4 (*M* = 3.50, *SD* = 1.24), followed by Test 2 (*M* = 3.45, *SD* = 1.70) and

Test 3 (*M* = 3.40, *SD* = 1.39). Students had the lowest mean score in the pre-test (*M* = 0.65, *SD* = 0.75) followed by the delayed post-test (*M* = 1.50, *SD* = 1.28). The mean score of Test 1 and the post-test was 2.30 (SD = 1.30) and 2.65(*SD* = 1.31), respectively.

Table 4.4 Descriptive Statistics Overall

	N	Minimum	Maximum	Mean		Std. Deviation	Skewness	Kurtosis
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic
Pre-test	20	0	2	0.65	0.167	0.745	0.697	-0.762
Test 1	20	0	5	2.30	0.291	1.302	0.331	-0.484
Test 2	20	1	6	3.45	0.380	1.701	-0.083	-1.017
Test 3	20	1	6	3.40	0.311	1.392	0.359	-0.503
Test 4	20	1	6	3.50	0.276	1.235	0.000	-0.152
Post-test	20	0	5	2.65	0.293	1.309	-0.208	-0.595
Delayed post-test	20	0	4	1.50	0.286	1.277	0.253	-1.090

Table 4.5 represents descriptive statistics and the comparison between the SCV and PRV groups based on test performance. The results show that the mean score of the SCV group is high compared to the mean score of the PRV group in the pre-test, Test 2, Test 3, Test 4, and delayed post-test, whereas for the SCV group the mean score of Test 1 and post-test was found to be low compared to the PRV group.

Table 4.5 Descriptive statistics and comparison between SCV and PRV on test performance

Group		N	Mean	Std. Deviation	Std. Error Mean
Pre-test	PRV	10	0.60	0.843	0.267
	SCV	10	0.70	0.675	0.213
Test 1	PRV	10	2.40	1.578	0.499
	SCV	10	2.20	1.033	0.327
Test 2	PRV	10	3.10	1.729	0.547
	SCV	10	3.80	1.687	0.533
Test 3	PRV	10	3.20	1.317	0.416
	SCV	10	3.60	1.506	0.476
Test 4	PRV	10	3.20	0.789	0.249
	SCV	10	3.80	1.549	0.490
Post-test	PRV	10	2.90	1.287	0.407
	SCV	10	2.40	1.350	0.427
Delayed post-test	PRV	10	1.20	1.229	0.389
	SCV	10	1.80	1.317	0.416

The independent samples *t*-test was used to compare the average value between the two groups. Table 4.6 presents the *t*-test results, which were used to compare the SCV and PRV groups for all tests (pre-test, Test 1, Test 2, Test 3, Test 4, post-test, and delayed post-test). The results show that $p > 0.05$ in all tests. Therefore, it can be concluded that there is no statistically significant difference between the average values of the SCV and PRV groups with respect to all the tests.

Table 4.6 T-test between SCV and PRV

	t-test for Equality of Means						
						95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Pre-test	-0.293	18	**0.773**	-0.100	0.342	-0.818	0.618
Test 1	0.335	18	**0.741**	0.200	0.596	-1.053	1.453
Test 2	-0.917	18	**0.372**	-0.700	0.764	-2.305	0.905
Test 3	-0.632	18	**0.535**	-0.400	0.632	-1.729	0.929
Test 4	-1.091	18	**0.289**	-0.600	0.550	-1.755	0.555
Post-test	0.848	18	**0.408**	0.500	0.590	-0.739	1.739
Delayed post-test	-1.053	18	**0.306**	-0.600	0.570	-1.797	0.597

4.2.2.2 Paired Samples t-Test

The paired samples *t*-test compares the means between two related groups on the same continuous dependent variable (Field, 2018). A paired sample *t*-test was used to understand whether differences in abilities existed to solve mathematical word problems within the same groups (SCV or PRV). Thus, the dependent variable was the mathematical word problem-solving ability, and the tests were the pre-test, post-test, and delayed test. The objective for using the paired samples *t*-test was to understand the impact of the experiment instrument (pre-test, post-test, and delayed post-test) within the same group.

The paired samples *t*-test null hypothesis is that no significant differences exist among the means of two related groups (Pallant, 2016):

$H_0: \mu_1 = \mu_2$

This means that, for example, if the pairing was between the pre-test and the post-test for the participant using PRV, and the paired samples *t*-test was not significant, the null hypothesis would be confirmed. According to Pallant (2016), getting a significant result rejects the null hypothesis of the paired sample *t*-test:

$H_A: \mu_1 \neq \mu_2$

For example, if the pairing was between the post-test and delayed test for participants using SCV and the result was significant, it would indicate a significant difference between both conditions.

4.2.2.2.1 Paired Samples t-Test Findings

Table 4.7 shows the results of paired sample statistics corresponding to the pairs of pre-, post-, and delayed post-tests. Results of the analysis show that the average score of the post-test (M = 2.65, SD = 1.31) was high compared to the average score of the pre-test (M = 0.65, SD = 0.75). Therefore, it can be concluded that students did show improvement during the study. Furthermore, the average score of the delayed test (M = 1.5, SD = 1.28) was high compared to the average score of the pre-test (M = 0.65, SD = 0.75). The average score of the delayed post-test (M = 1.5, SD = 1.28) was low compared to the average score of the post-test (M = 2.65, SD = 1.31).

Table 4.7 Paired sample statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test	0.65	20	0.745	0.167
	Post-test	2.65	20	1.309	0.293
Pair 2	Pre-test	0.65	20	0.745	0.167
	Delayed post-test	1.50	20	1.277	0.286
Pair 3	Post-test	2.65	20	1.309	0.293
	Delayed post-test	1.50	20	1.277	0.286

Table 4.8 shows the result of the paired samples *t*-test. The paired samples *t*-test was adopted to compare the pre-test, post-test, and delayed post-test pairwise. The results show that the average difference between the pre-test and post-test is -2.00 ($t(19) = -5.75$, $p < 0.001$); as this difference is statistically significant, it can be concluded that students showed more improvement in the post-test compared to the pre-test. Again, a statistically significant difference was found between the average score of the pre-test and delayed post-test ($t(19) = -3.00$, $p = 0.007$, mean difference = -0.850); therefore, it can be concluded that, on average, students improved on the pre-test compared to the delayed post-test. A statistically significant difference was also found between the post-test and delayed post-test ($t(19) = 3.09$, $p = 0.006$, mean difference = 1.150). From the results obtained, it can be concluded that, on average, students obtained lower scores on the delayed post-test compared to the post-test.

Table 4.8 Paired sample t-test overall

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Pre-test - Post-test	-2.000	1.556	0.348	-2.728	-1.272	-5.748	19	**0.000**
Pair 2	Pre-test – Delayed post-test	-0.850	1.268	0.284	-1.443	-0.257	-2.998	19	**0.007**
Pair 3	Post-test – Delayed post-test	1.150	1.663	0.372	0.372	1.928	3.092	19	**0.006**

Table 4.9 shows the result of the paired samples *t*-test for the PRV group. The paired samples *t*-test was adopted to compare the pre-, post-, and delayed post-test pairwise for the PRV group. The results show a statistically significant difference between the pre-test and post-test ($t(9) = -4.87$, $p = 0.001$, mean difference = -2.30), implying that students in the PRV group did better on the post-test compared to the pre-test. A statistically significant difference was also found between the post-test and delayed post-test ($t(9) = 2.94$, $p = 0.016$, difference = 1.70). From the results obtained, it can be concluded that, in the PRV group, the students got lower scores on the delayed post-test compared to the post-test. Moreover, in the PRV condition for pair 2 (i.e. pre-test and delayed post-test), the difference was found to be statistically insignificant as ($t(9) = -1.964$, $p = 0.081$, difference = -0.600). Therefore, it can be concluded that, the PRV group students got a better score on the delayed post-test compared to the pre-test.

Table 4.9 Paired sample t-test – PRV group

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pre-test – post-test	-2.300	1.494	0.473	-3.369	-1.231	-4.867	9	**0.001**
Pair 2	Pre-test – delayed post-test	-0.600	0.966	0.306	-1.291	0.091	-1.964	9	**0.081**
Pair 3	Post-test – delayed post-test	1.700	1.829	0.578	0.392	3.008	2.940	9	**0.016**

Table 4.10 shows the result of the paired samples *t*-test for the SCV group. The paired samples *t*-test was used to compare the pre-, post-, and delayed post-test pairwise for the SCV group. The results show a statistically significant difference between the pre-test and post-test ($t(9) = -3.28$, $p = 0.009$, mean difference = -1.70), therefore, it can be concluded that students in the SCV group did better on the post-test compared to the pre-test. A statistically significant difference was also found between the average scores of the pre-test and delayed post-test ($t(9) = -2.28$, $p = 0.048$, mean difference = -1.10); as this difference is statistically significant, it can be concluded that students scored lower on the pre-test compared to the delayed post-test. Furthermore, a statistically insignificant difference was found between the post-test and delayed post-test ($t(9) = 1.41$, $p = 0.193$, mean difference = 0.60). From the results obtained, it can be concluded that, in the SCV group, students got higher scores on the post-test compared to the delayed post-test.

Table 4.10 Paired sample t-test – SCV group

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pre-test – post-test	-1.700	1.636	0.517	-2.871	-0.529	-3.285	9	**0.009**
Pair 2	Pre-test – delayed post-test	-1.100	1.524	0.482	-2.190	-0.010	-2.283	9	**0.048**
Pair 3	Post-test – delayed post-test	0.600	1.350	0.427	-0.366	1.566	1.406	9	**0.193**

4.2.3 Correlation Test Results

4.2.3.1 Testing the Correlation Test Assumptions

It was important before applying the correlation test to test the correlation test assumptions. Figures 4.2, 4.3., and 4.4 show the linearity test for each test (pre-test, post-test, and delayed test) and the frequency of using SCV in these tests. It can be observed that the points are almost linear. Additionally, Figures 4.2, 4.3, and 4.4 show some outliers. The fourth assumption tests the normal distribution, where variables should be approximately normally distributed.

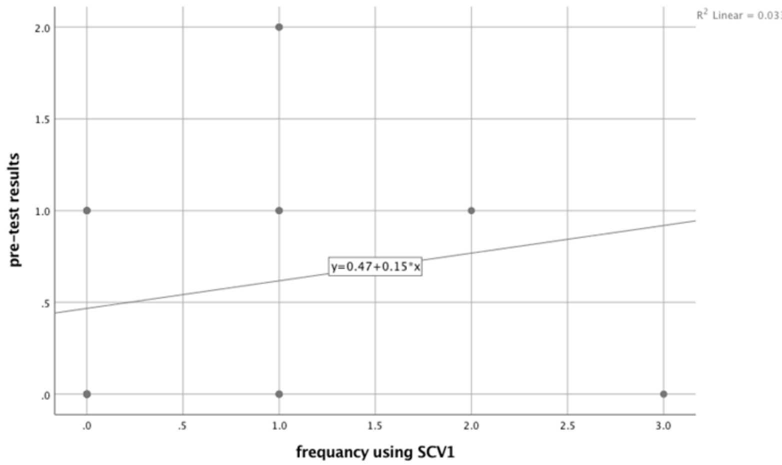


Figure 4.2 Testing linearity between the pre-test and frequency of using SCV

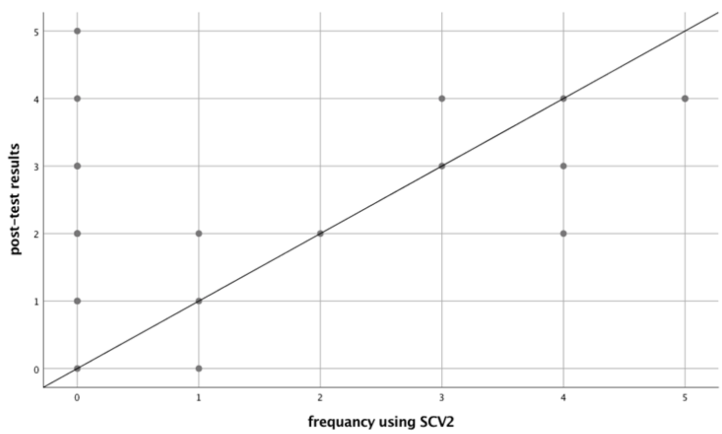


Figure 4.3 Testing linearity between the post-test and frequency of using SCV

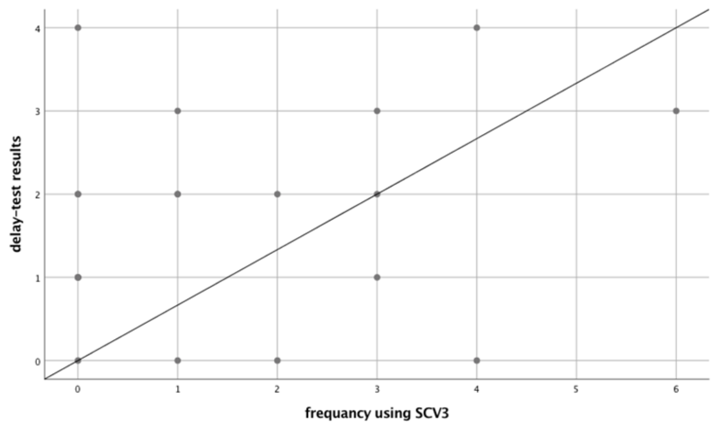


Figure 4.4 Testing linearity between the delayed test and frequency of using SCV

Table 4.11 shows the data are not normally distributed for some results and normally distributed for other results.

Table 4.11 Normality test by Shapiro-Wilk

	Df	Sig
Pre-test results	20	.000
Frequency using SCV in the Pre-test	20	.000
Post-test results	20	.219
Frequency using SCV in the Post-test	20	.001
Delayed test results	20	.081
Frequency using SCV in the Delayed test	20	.003

4.2.3.2 Findings of The Correlation Test

Table 4.12 shows the frequency of using SCV by both SCV and PRV students in the pre-test, post-test, and delayed post-test. The table indicates that very few students were using SCV while solving the pre-test; these students used SCV in their pre-test because their teachers were applying a similar strategy in their mathematics class, as the interview data demonstrated when students indicated whether they had used SCV before or their teachers had used similar methods in mathematical class. Some of these students stated that their teachers had used a similar strategy while solving certain mathematical problems. However, they had not used this strategy to solve mathematical word problems; providing a visual translation of mathematical word problems into images, as in the current study. This point was clarified in the teachers' interview data. All these above reasons explained why so few students used SCV in the pre-test.

In spite of insufficient use of SCV in the pre-test, Table 4.12 shows an improvement when using SCV in the post-test, compared to the pre-test. This is clear from the scatterplot in sub-section 4.2.3.1 Testing the Correlation Test Assumptions (see Figures 4.2, 4.3 and 4.4), which revealed an increase in the use of SCV in the post-test and delayed post-test, where the scatterplot line goes upward, especially in relation to the post-test and delayed post-test. For example, in Table 4.12, Girl No. 2 did not use any SCV in her pre-test, but she did in her post-test for four of the six questions as well as for three questions on her delayed test. Table 4.12 shows similar improvements in SCV were found for Girl No. 1 and Girl No. 4. Interestingly, Girl No. 3 in Table 4.12 used SCV in her pre-test, but she did not use it in the post-test or delayed test.

Boys in the SCV group did not show great improvement in using SCV through the three tests (see Table 4.12). They did not use SCV as the girls did. Arguably, the girls preferred using SCV more than boys did, which was clear by Table 4.12. In addition, regarding to preference for using SCV, the intervention looked to have more effect on girls than boys, because the girls continued using SCV in their post-test and delayed post-test more than the boys (see Table 4.12). This result can indicate that the girls outperformed the boys when using SCV while solving mathematical word problems. Notably, Boy No. 6 in Table 4.12 did not apply the SCV in the pre-test or post-test, but he suddenly used it in the delayed test. It could be suggested that using SCV developed the student's ability to recall the existing experience (SCV) to solve mathematical word problems.

Table 4.12 shows an interesting result in relation to students in the PRV group using SCV in the pre-test, post-test, and delayed post-test. Some PRV students seemed to use SCV in all three tests, where they only used SCV in the reversal session. Therefore, using PRV might have helped PRV students recall information in the form of SCV.

Table 4.12 Using SCV for students with ADHD in the pre-test, post-test and delayed test

Student	Gender	Group	Pre-test result	Frequency of SCV usage	Post-test result	Frequency of SCV usage	Delayed test result	Frequency of SCV usage
1	Girl	SCV	0/6	1/6	3/6	3/6	4/6	4/6
2	Girl	SCV	1/6	0/6	2/6	4/6	1/6	3/6
3	Girl	SCV	1/6	2/6	5/6	0/6	4/6	0/6
4	Girl	SCV	1/6	1/6	4/6	3/6	3/6	6/6
5	Boy	SCV	2/6	1/6	1/6	1/6	1/6	0/6
6	Boy	SCV	1/6	0/6	1/6	0/6	2/6	3/6
7	Boy	SCV	1/6	1/6	2/6	0/6	0/6	1/6
8	Boy	SCV	1/6	0/6	1/6	0/6	2/6	0/6
9	Boy	SCV	2/6	1/6	3/6	4/6	1/6	0/6

10	Boy	SCV	0/6	0/6	2/6	0/6	2/6	1/6
11	Girl	PRV	0/6	0/6	4/6	4/6	0/6	2/6
12	Girl	PRV	0/6	3/6	2/6	2/6	3/6	3/6
13	Girl	PRV	0/6	0/6	0/6	1/6	0/6	4/6
14	Girl	PRV	0/6	0/6	4/6	5/6	2/6	2/6
15	Boy	PRV	0/6	0/6	4/6	5/6	1/6	0/6
16	Boy	PRV	0/6	0/6	3/6	0/6	1/6	0/6
17	Boy	PRV	0/6	1/6	3/6	0/6	3/6	1/6
18	Boy	PRV	0/6	0/6	2/6	1/6	2/6	1/6
19	Boy	PRV	1/6	0/6	4/6	0/6	2/6	0/6
20	Boy	PRV	0/6	0/6	0/6	0/6	0/6	0/6

Before reporting the results of the correlation test, it is important to determine the strength of its relationships. Pallant (2016) reported that low correlation can be identified, if the correlation coefficient (r) is between .1 and .29; medium correlation is identified if (r) is between .30 and .49, and high correlation is identified if (r) is between .5 and 1.0. The correlation test in Table 4.13, using Spearman's correlation coefficient, shows statistically insignificant low correlation results for the delayed post-test alone ($r = .244$, $p > .05$). The correlation test for the pre-test in Table 4.13 shows ($r = .306$, $p > .05$); indicating a statistically insignificant medium correlation between the frequency of using SCV and the pre-test. Additionally, Table 4.13 shows ($r = .345$, $p > .05$) for the post-test, indicating a statistically insignificant medium correlation between the frequency of using SCV and the post-test.

Even if Table 4.13 showed a low to medium correlation between using SCV and the test scores, that relationship would be insignificant. Additionally, the low to medium correlation between the use of SCV and the test scores is positive, where the correlation line is upward, as shown in Figures 4.2, 4.3 and 4.4, It is also clarified in Table 4.13 that all the correlation coefficients show a positive sign (no negative sign in front of the correlation coefficient).

Table 4.13 Correlation test Using Spearman’s Rho

	Correlation Coefficient	Sig
Pre-test results and frequency using SCV	.306	.190
Post-test results and frequency using SCV	.345	.137
Delayed test results and frequency using SCV	.244	.300

4.3 Discussion

The study yielded several findings on whether SCV (i.e. images that students create themselves to represent word problems visually) can help students with ADHD solve mathematical word problems better than PRV (i.e. given images that come with word problems). In order to provide an answer to the first research problem (*To what extent do PRV and SCV help students with ADHD solve mathematical word problems?*), two parametric tests (independent samples *t*-test and paired sample *t*-test) and correlation tests were used.

4.3.1 Comparison of SCV and PRV

As it was believed that creating a public artefact to externalise the students’ thinking (Papert, 1993) is more effective to learn, it was reasonable to believe that using public artefacts can help learners gain knowledge and develop new ideas (Papert, 1993). Papert’s constructionist theory broadly underpins the current study as a lens through which to understand mathematics learning. The interpretation between the current study and Papert's theory was how students could learn mathematical word problems better using SCV while creating or constructing a drawing compared to PRV, which is when images of objects are given to students. Therefore, the first research question was developed to provide an answer to the comparison between SCV and PRV and determine which one affects learning mathematical word problems better.

In order to answer the first research question and understand which tool (SCV or PRV) has an impact on ADHD students' mathematical ability to solve word problems, an independent samples *t*-test was applied. The results from the independent samples *t*-test revealed no statistically significant difference between the use of SCV and PRV. This addresses the first research question. According to Papert's (1993) view of constructionism, SCV should be more effective than PRV, where learning is developed by learners projecting out their current understanding of a given topic (Ackermann, 2001). In addition, the act of drawing creates a public artefact which can facilitate learning (Papert, 1993). Arguably, the current intervention study indicates an equivalent impact on learners in both the SCV and PRV groups, with $p > 0.05$ in all tests.

As discussed by Halpenny and Pettersen (2014), Piaget highlighted that developing cognitive abilities differs according to each child. Moreover, according to Piaget's constructivism theory, children construct their knowledge and understanding based on their own experiences (Halpenny & Pettersen, 2014). Therefore, students refer to their existing experience of using SCV with their teachers, where some of these students used SCV in their pre-test (see the correlation test results in section 4.2.3.2).

Among the plausible explanations for independent samples *t*-test findings, as discussed by Sorva et al. (2013), visualisation allows the construction of knowledge, explaining the results that students with ADHD in both groups (i.e. SCV and PRV) showed insignificant statistical differences in solving mathematical word problems. As students in both groups had the same experience of using visualisation, the present findings also support Bruner's (1966) view, which highlighted that using visualisation can improve the abilities to develop the mental image.

The present findings also suggest that Papert's (1993) theory of constructionism is not applicable for the current study, as students with ADHD, who created their visualisation (SCV), or did not create their visualisation (PRV), showed no differences in their ability to solve mathematical word problems. The most striking conclusion to emerge from the data is that both groups of student could develop a new concept of mathematical learning, which Skemp (1989) referred to as rational learning—namely, students can think about how to solve the problem and why this is the answer—rather than instrumental understanding, which depends on memorising the information without understanding. Furthermore, Kilpatrick et al. (2001) offered a similar view about the procedural fluency and conceptual understanding. Therefore, it could be suggested that both types of students might develop the same ability of rational learning and conceptual understanding; indeed, students in both groups showed similarities in solving mathematical word problems. Some SCV students did not use SCV while solving mathematical word problems whereas some PRV students used SCV, thereby establishing a balance in the results between SCV and PRV groups.

Regarding the experimental procedure and design, the non-significant difference could be related to students in the SCV group receiving directions that they could draw whatever they wanted in order to express their understanding, which might have confused them about what they should draw or made them take time to think about how to express the problems, unlike the PRV students, who received clear and good quality pictures. This supports the finding of Van Meter et al. (2006), who reported that students who received instruction on generating drawings demonstrated better results. Therefore, instructions about what to draw accurately or training about how to draw to solve mathematical word problems might change the current results.

4.3.2 Improvement of Both the SCV and PRV Groups

As highlighted in the literature, using visualisation can help improve mathematical understanding by enhancing cognitive ability through the development of mental images (Hershkowitz et al., 2001; Arcavi, 2003; Giaquinto, 2011). Therefore, the current intervention study led to unexpected results, where both SCV and PRV showed statistically insignificant differences in the impact of using SCV compared to PRV. However, consistent with Bruner's (1966) view of representation which increases the abilities of manipulation and recalls the information, the current study found that using visual representation to solve mathematical word problems improved the ability of students with ADHD to solve word problems.

The paired sample *t*-test demonstrated that students in both groups (SCV and PRV) showed statistically significant differences between the pre-test and post-test, developing their ability to solve mathematical word problems. The result is in line with earlier literature (Tsai & Yen, 2013; Garderen et al., 2014; Teahen, 2015) that found students with special need and students in general benefit from using visualisation in mathematics learning. For example, Arcavi (2003) suggested that using visualisation not only helps reach a solution, but also teaches students the analytical process of thinking about the solution. This can clarify the reason for the similar improvement of the SCV and PRV groups in solving mathematical word problems, as both seemed to develop similar abilities using visualisation. Therefore, using Bruner's (1966) iconic mode of representation, created according to Papert's (1993) constructionist theory (drawing) or through a given image (PRV), both showed similar impacts on ADHD students' ability to solve mathematical word problems.

The interesting finding from the paired sample *t*-test was that students in the PRV group showed statistically significant differences between the post-test and the delayed test, but students in the SCV group did not. This raises a question about whether using images has a more long-lasting effect on students with ADHD than drawing or if the ADHD students in the SCV group failed to use the intervention, whereas students in the PRV group succeeded. Furthermore, what Bruner (1966), Arcavi (2003) and Tall (2004) discussed about how visualisation can enhance cognitive ability through the development of mental images is true, but it could be argued that Bruter's (2013) view of visualisation helps in the establishment of more robust memories because these concrete images are more comfortable to recall, as was applied for students in the PRV group more than students in the SCV group. This result could also mean that students in the SCV group failed to transfer from Bruner's (1966) iconic mode to the symbolic mode of representation, suggesting it "may be possible to by-pass the first two stages. However, one does so with the risk that the learner may not possess the imagery to fall back on when his symbolic transformation fails to achieve a goal in problem-solving" (p.49). Therefore, further studies are needed to explore these issues to dig deeper in the mental image and the ability to recall the information.

4.4 Summary

This chapter helped answer the first research question (*To what extent do PRV and SCV help students with ADHD to solve mathematical word problems?*). Two types of parametric statistical tests were used: an independent samples *t*-test and a paired samples *t*-test. The independent samples *t*-test was used to compare mathematical abilities to solve mathematical word problems of students in the PRV and SCV groups, whereas the paired samples *t*-test was used for comparisons of test scores of the same children over a period of time.

Based on the results from the independent samples *t*-test, there is no statistically significant difference between the average scores of the SCV and PRV groups with respect to all tests. However, the result from the paired samples *t*-test indicated that, on average, students showed improvement in the study before the post-test. In addition, for the PRV group, the results showed a significant difference between the pre-test and post-test and the post-test and delayed test only; test pairwise comparisons for the SCV group showed no significant differences between the post-test and delayed test. This suggests that using SCV might not have a significant impact in solving mathematical word problems for students with ADHD, compared to using PRV, as both groups showed similar improvement.

CHAPTER 5: ANALYSIS AND FINDINGS FOR RESEARCH QUESTION TWO

5.1 Introduction

This chapter details the analysis of the observation data collected during the experimental design sessions to answer the second research question (*To what extent do PRV and SCV help students with ADHD remain focused while solving mathematical word problems?*). As discussed in the research design section in the methodology chapter (see Chapter 3), observation data were collected to understand the impact of the intervention on ADHD students' focus while solving mathematical word problems compared to the effect on the comparison group. This chapter outlines the preparatory analysis carried out—namely, the data collection procedure; the statistical analysis, which highlights the testing distribution and the test selection; and the results of observing each student across the 20 sessions.

5.2 Statistical Tools

After collecting all the observational data, the data were entered into SPSS (Version 25). The adoption of a regression test helped explore the differences in the instances of ADHD behaviour among the intervention group compared with the comparison group. Therefore, the primary goal of using the regression test as a statistical tool was to confirm or reject the null hypothesis of the observation study:

> H0: There is no significant effect of using SCV compared to PRV on ADHD students' behaviour of remaining focused while doing mathematical word problems.

The proposed hypothesis was:

> H1: There is a significant effect of using SCV compared to PRV on ADHD students' behaviour of remaining focused while doing mathematical word problems.

Before applying the regression, normality assumptions were tested (see below).

5.2.1 Regression Test Assumptions

In order to ensure robust measurement and tests, it is important to test normality by exploring the distribution (Larson-Hall, 2015; Field, 2018). As discussed in the previous section, testing the distribution can be done by testing the distribution assumptions of normality, linearity, and homoscedasticity (Pallant, 2016; Field, 2018). The present study used different ways to test the distribution of the data before selecting a statistical test. The distribution assumptions tested for the observation included:

- Normality (Shapiro-Wilk test as well as skewness and kurtosis tests)
- Linearity (regression line)
- Homoscedasticity (Levene test).

Testing these assumptions helped determine if it was possible to use a parametric or non-parametric test. The assumptions of the distribution to use a *linear regression test* and an appropriate statistical test will be discussed next.

The normality test assumes that the distribution of the data is tentatively normal in distribution (Brear, 2017). Two normality tests were used to test the distribution of the observations: the Shapiro-Wilk test and skewness and kurtosis tests. The Shapiro-Wilk test was used because, as previously discussed, it is more suitable for a small sample size (Field, 2018). According to Field (2018), the Shapiro-Wilk test indicates that the data are normally distributed if $p > 0.05$. However, the data significantly differ from a normal distribution if $p < 0.05$. By using the "Explore" command in SPSS, as shown in Table 5.1, the Shapiro-Wilk test result indicated that the data for both observation categories (inattention as well as hyperactivity and impulsivity) for each group (SCV and PRV) were normally distributed.

Table 5.1 Shapiro-Wilk test

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Group_C	Statistic	df	Sig.	Statistic	df	Sig.
Inattention	PRV	.192	10	.200*	.949	10	**.660**
	SCV	.167	10	.200*	.933	10	**.476**
Hyperactivity and Impulsivity	PRV	.126	10	.200*	.963	10	**.823**
	SCV	.182	10	.200*	.955	10	**.725**

Second, skewness and kurtosis tests were used to support the objective judgement of normality from the Shapiro-Wilk test. Using a different type of normality test helps develop a comprehensive overview of the validity of the data distribution before the selection of the statistical test. The moderation of (normally distributed data) skewness and kurtosis tests is between -0.05 and 1 or between 0.05 and 1 (Field, 2018). As Table 5.2 demonstrates, skewness and kurtosis test results were moderate because both test results were near zero and between 0.05 and 1. The kurtosis test shows a negative sign, so the tail is light (Field, 2018). Therefore, the skewness and kurtosis tests confirmed the normality.

Table 5.2 Skewness and kurtosis tests

Statistics			
		Inattention	Hyperactivity
N	Valid	20	20
	Missing	0	0
Mean		.3900	.3613
Std. Error of Mean		.03142	.02688
Median		.3964	.3625
Mode		.14[a]	.40
Std. Deviation		.14050	.12022
Variance		.020	.014
Skewness		**.071**	**.251**
Std. Error of Skewness		.512	.512
Kurtosis		**-.495**	**-.920**
Std. Error of Kurtosis		.992	.992
Minimum		.14	.18
Maximum		.65	.59
Sum		7.80	7.23

5.2.1.1 Linearity

As discussed in the previous section, linearity indicates that two variables should have a linear relationship in regression (Pallant, 2016; Field, 2018). By using a linear regression in SPSS, as shown in Figure 5.1, the points plotted did not curve and showed a linear relationship with the regression line where the residual (error) is small. Therefore, the assumption of linearity was confirmed.

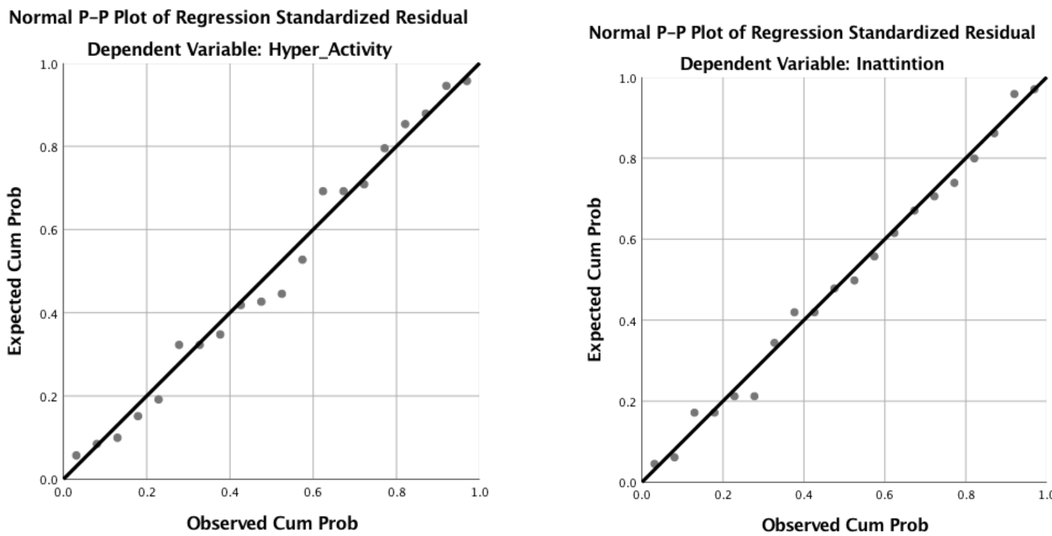


Figure 5.1 Normal P–P plot of regression standardized residual dependent variable: Group (PRV and SCV)

5.2.1.2 Homoscedasticity

Homoscedasticity is also called the homogeneity of variance. In order to test the ability to use a parametric test or if the data are normally distributed, the study assumed a homogeneity of variance among each group (SCV and PRV) for each observation category (inattention, hyperactivity, and impulsivity). To investigate the homogeneity of variance, the Levene test was used. The null hypothesis of the Levene test is that the variance should be equal for each group (Field, 2018). Consequently, the equal variances assumption is violated if the Levene test is significant (Field, 2018).

Table 5.3 displays a set of p values greater than 0.05. Values of the Levene test for the equality of variances, which was found to be violated for the present analysis for inattention, were $F(1,18) = 3.865$, $p = .065$, and for hyperactivity and impulsivity, $F(1,18) = .316$, $p = .581$. These results suggested that the variances for each group are equal. Hence, the assumption of distribution was inveterate.

Table 5.3 Levene test for the observation

Test of Homogeneity of Variance

		Levene Statistic	df1	df2	Sig.
Inattention	Based on Mean	**3.865**	1	18	**.065**
	Based on Median	2.428	1	18	.137
	Based on Median and with adjusted df	2.428	1	16.016	.139
	Based on trimmed mean	3.796	1	18	.067
Hyperactivity	Based on Mean	**.316**	1	18	**.581**
	Based on Median	.406	1	18	.532
	Based on Median and with adjusted df	.406	1	17.994	.532
	Based on trimmed mean	.329	1	18	.573

Tables 5.4 and 5.5 show the results of the Durbin-Watson test for ADHD inattention and hyperactivity/impulsivity items for both groups (SCV and PRV). These tables also show R, which is the simple correlation, and R square, which shows the total number of the variations in the dependent variable that can be explained by the independent variable.

Table 5.4 Durbin-Watson test for ADHD inattention items for SCV and PRV groups

Inattention Items	**Durbin-Watson Test**	**R Square**	**R**
Missing details and the work is inaccurate	1.545	.689	.830
Difficulties remaining focused on tasks	1.988	.811	.901
Mind seems elsewhere	1.483	.715	.845
Easily distracted	1.647	.739	.860
Difficulties organizing the task	1.469	.658	.811

Avoids engagement in tasks	.628	.574	.757
Forgets daily activities	1.186	.596	.772

Table 5.5 Durbin-Watson test for ADHD hyperactivity/impulsivity items for SCV and PRV groups

Inattention Items	**Durbin-Watson Test**	**R Square**	**R**
Taps hands or feet	1.188	.664	.815
Squirms in the seat	1.155	.566	.752
Often leaves the seat, does not remain seated	1.399	.545	.738
Runs or climbs in inappropriate situations	.444	.410	.640
Uncomfortable staying still for an extended time	.968	.700	.837
Talks excessively	1.201	.566	.753

Tables 5.4 and 5.5 show a high correlation between students' ADHD behaviour in both groups (SCV and PRV) and the number of sessions. As the number of sessions increased, the ADHD behaviour decreased. The percentage of the correlation presented by R in Tables 5.4 and 5.5 ranges between .901 as the highest score for inattention (Difficulties remaining focused on tasks) and .640 as the lowest score for hyperactivity/impulsivity (Runs or climbs in inappropriate situations). In addition, Tables 5.4 and 5.5 show that a large number of the dependent data can be explained by the independent data presented by R square; the highest percentage is 81% for inattention (Difficulties remaining focused on tasks), and the lowest percentage is 41% for hyperactivity/impulsivity (Runs or climbs in inappropriate situations).

According to Turner (2019), if the sample size is less than 100, the Durbin-Watson test should show a number less than six. Table 5.4 and 5.5 shows a number less than six; therefore, the linear regression test can be done. However, according to Field (2018), the Durbin-Watson test should not be less than 1 or greater than 2. The data in Tables 5.4 and 5.5 did not show any numbers greater than 2, but there are a few numbers less than 1. As long as the other regression assumptions have been met, one assumption violated in only two ADHD behaviour elements, as shown in Tables 5.4 and 5.5, can be ignored.

5.2.2 Regression Test

After testing the assumption of the distribution, as discussed in previous sections, it was found that using a parametric test was valid. During the study, observations were completed independently for each participant; therefore, the data for one student was not affected by the data of another student.

The objective of using the regression test was to compare the regression line and regression coefficient between the two observation groups (SCV and PRV) on the same dependent variable (inattention, hyperactivity, and impulsivity), where the independent variables were the two groups (SCV and PRV) and the number of sessions (20 sessions). This test helped establish whether a statistically significant difference existed in the ADHD behaviours of SCV and PRV students during the 20-session period.

5.2.2.1 Findings: Inattention

Some differences were observed between the PRV and SCV students with respect to different elements of inattention. Figures 5.2 to 5.8 show the pictorial representation of the differences between the PRV and SCV students for elements of inattention from the linear regression. The figures indicate that all elements of inattention decreased. To understand if these elements truly decreased, it was necessary to calculate the regression equation for both groups (SCV and PRV) to identify the differences between both regression equations. The difference between both regression equations indicated that the regression line for both groups within both groups shifted down along the *y* axis, thereby suggesting a decrease in students' inattention behaviours in both groups (SCV and PRV).

Y = constant + input (independent)

The regression equation is important, because it can give information about a finding. For example, if the sign indicated is (+), the regression line will go upward, but if it is (-), the regression line will go downward. Additionally, the constant number in a regression equation will reveal the distance between the two regression lines.

Each point in each figure was calculated from the ratio of the appearance of the element. For example, in Figure 5.2, point 0.8 along the *y* axis refers to the second session on the *x* axis, meaning that 16 students in the second session were missing details and their work was inaccurate. They received a score of 1. However, the 4 students who did not show that element received a score of 0. To calculate the ratio of students showing the element, the following equation was used:

The number of students with a score of 1 / their number = the ratio

To calculate the percentage, the ratio was multiplied by 100:

Percentage = ratio x 100

For the previous example, the percentage of students with missing details and inaccurate work in Session 2 was 80%, while 20% did not show this element (see the example in Table 5.6 about how to develop Figures 5.2 to 5.8 from the ratio in the Table; all subsequent Figures were developed in the same way).

Table 5.6 Data for each student: 'Missing details' factor and calculated ratio

Student PRV	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1	1	1	1	0	0	0	1	1	1	1	1	1	0	0	0	0	1	0	0
2	1	1	1	0	0	0	1	1	1	0	1	1	1	0	0	1	0	0	0	0
3	1	1	0	0	0	0	0	0	1	0	0	1	0	1	1	0	0	0	0	0
4	0	1	0	1	0	1	0	1	1	0	1	1	1	1	0	1	0	0	0	0
5	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
6	1	1	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
7	1	1	1	1	1	0	1	1	1	0	0	1	0	0	1	1	0	0	0	0
8	1	1	1	1	1	0	1	0	1	0	1	0	0	0	1	1	0	0	0	1
9	1	1	1	1	0	1	1	0	0	0	1	1	1	0	0	0	0	1	0	0
10	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
Ratio	.9	1	.7	.6	.4	.5	.6	.6	.8	.4	.7	.8	.5	.3	.4	.5	.1	.2	0	.1
Student SCV	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1	0	0	0	0	1	0	0	0	0	1	1	0	1	1	0	1	1	0	1
2	1	1	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
3	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
4	1	1	1	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
5	1	0	0	1	0	0	1	1	1	1	0	0	1	0	0	0	0	0	0	0

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

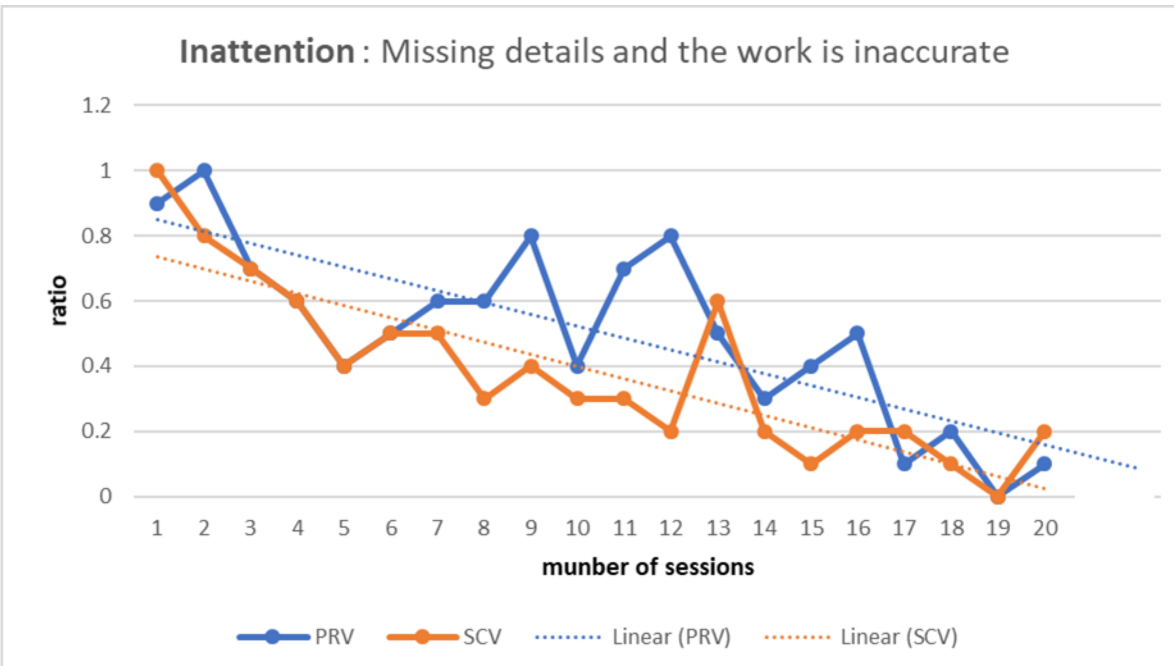


Figure 5.2 Missing details and the work is inaccurate

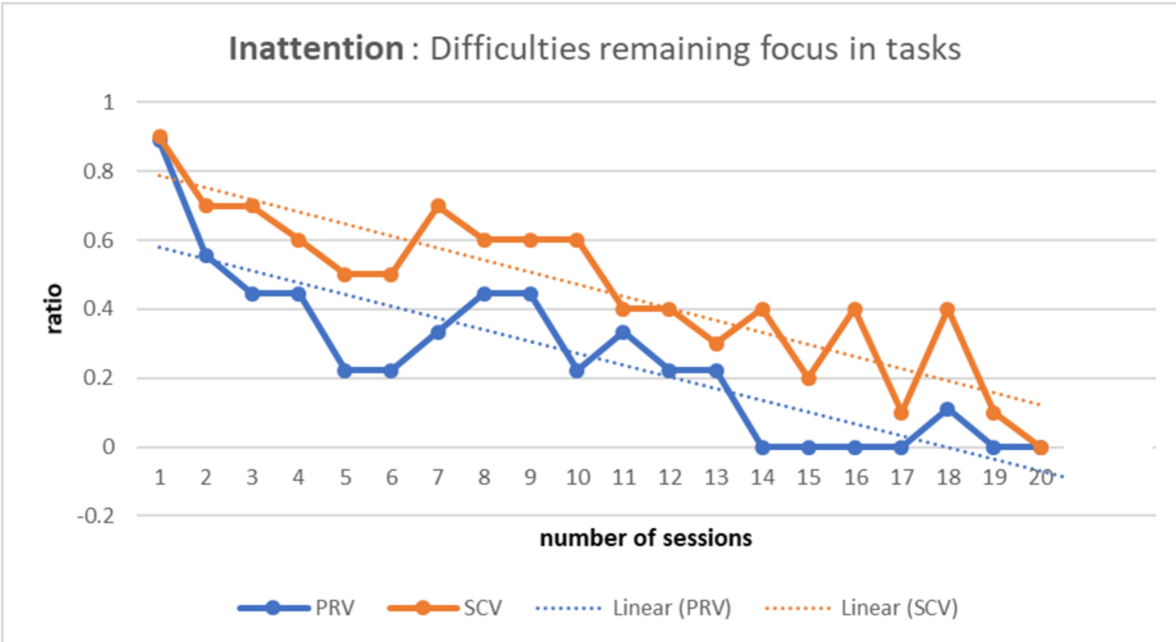


Figure 5.3 Difficulties remaining focused on tasks

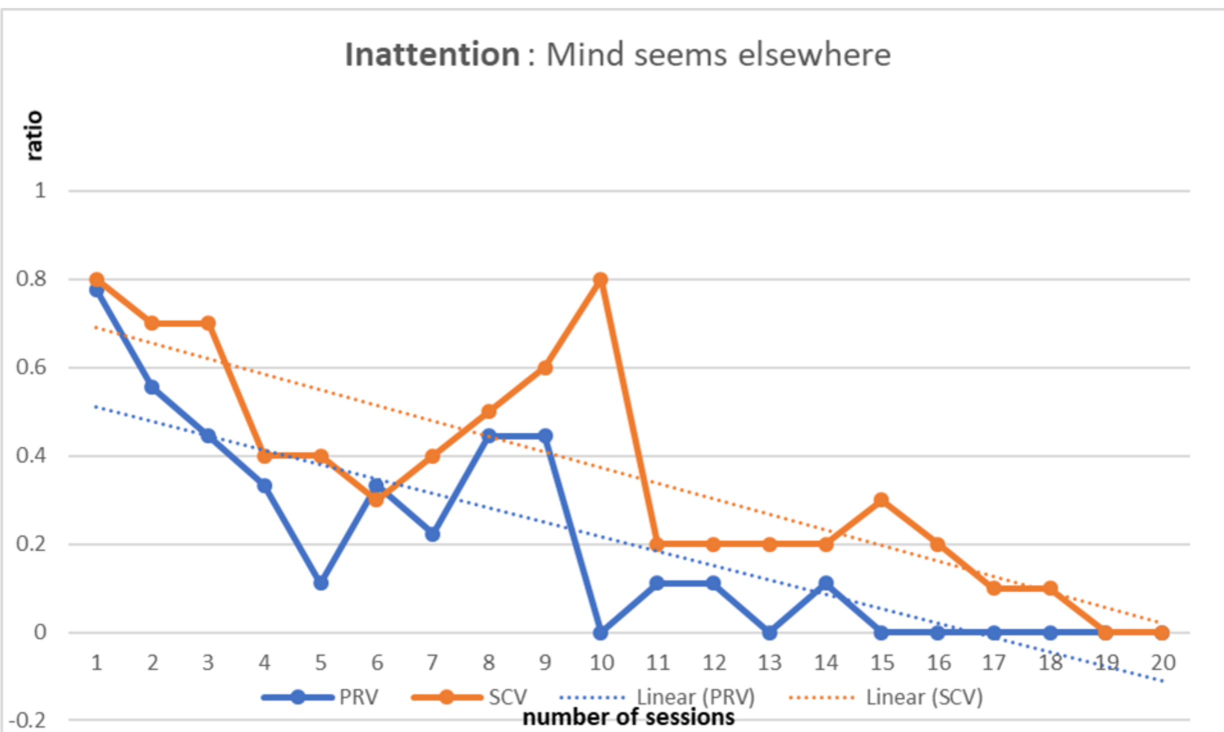


Figure 5.4 Mind seems elsewhere

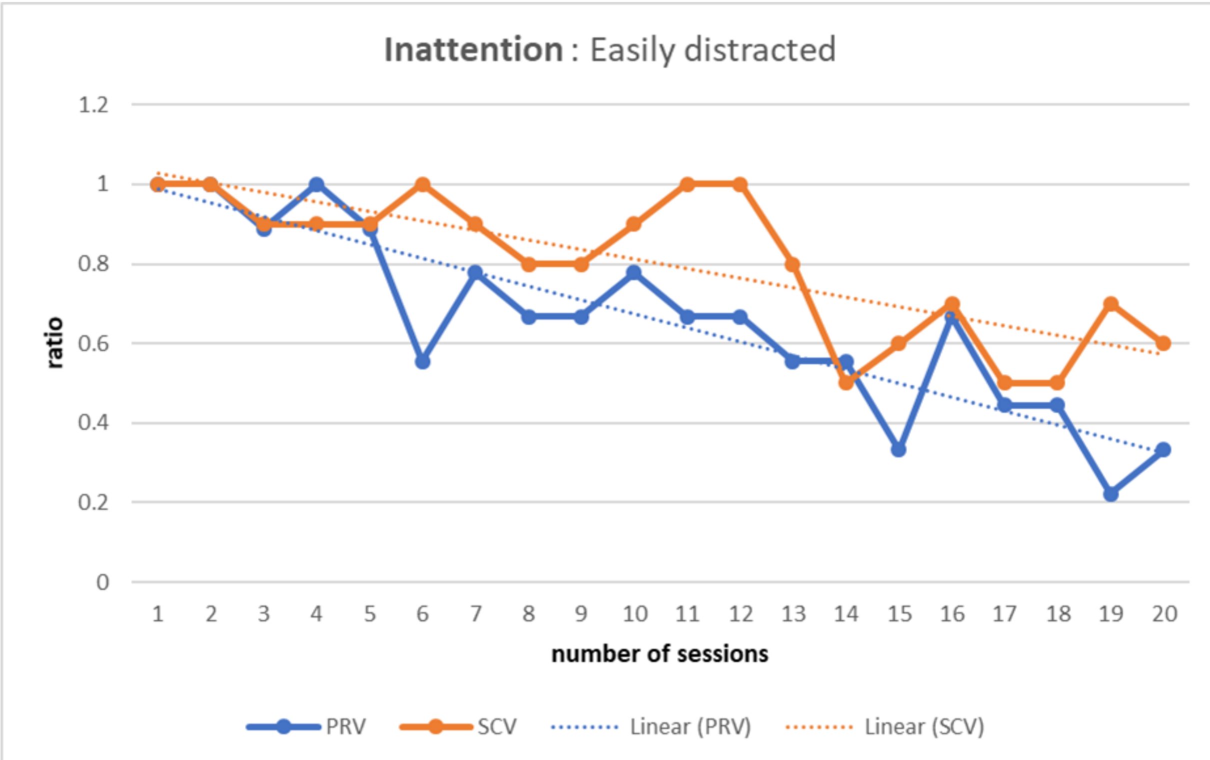


Figure 5.5 Easily distracted

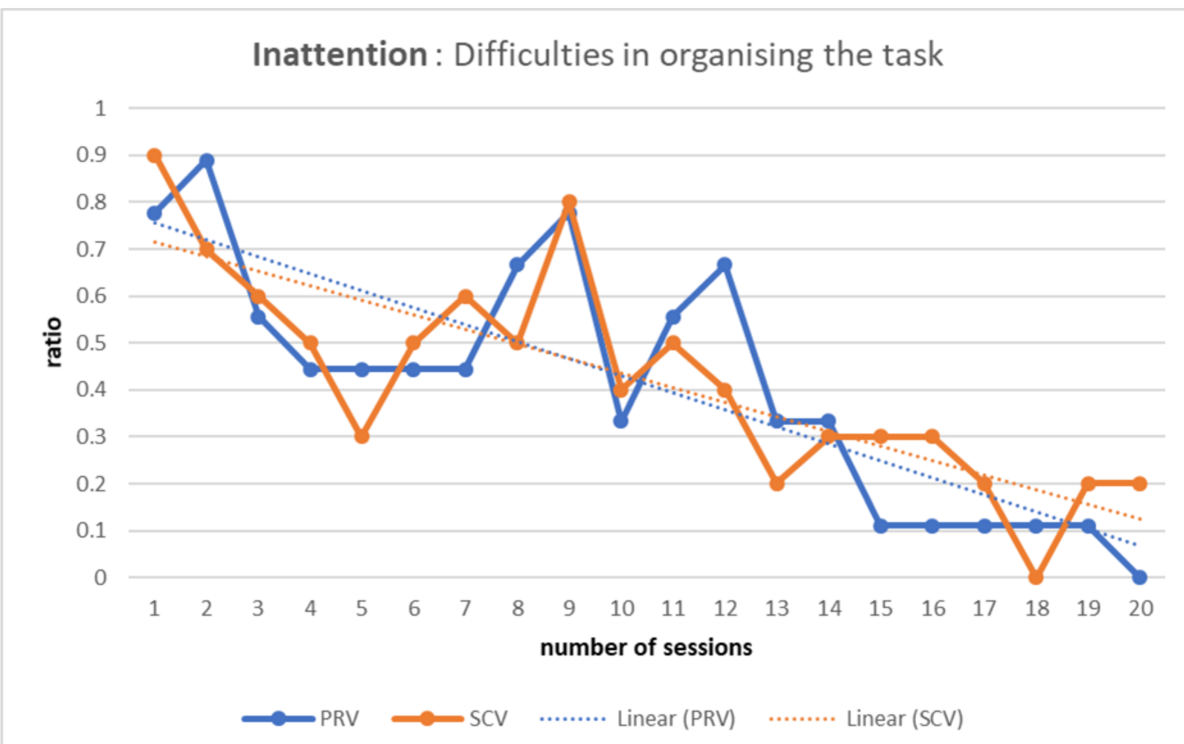


Figure 5.6 Difficulties in organising tasks

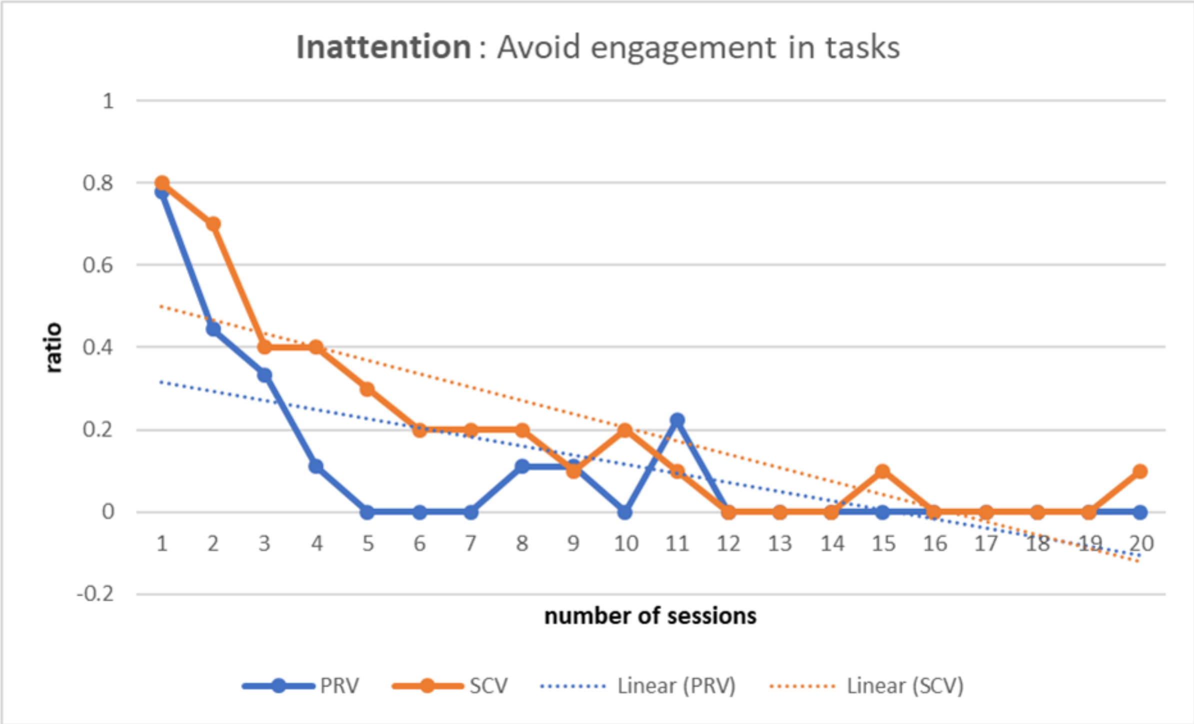


Figure 5.7 Avoiding engagement in tasks

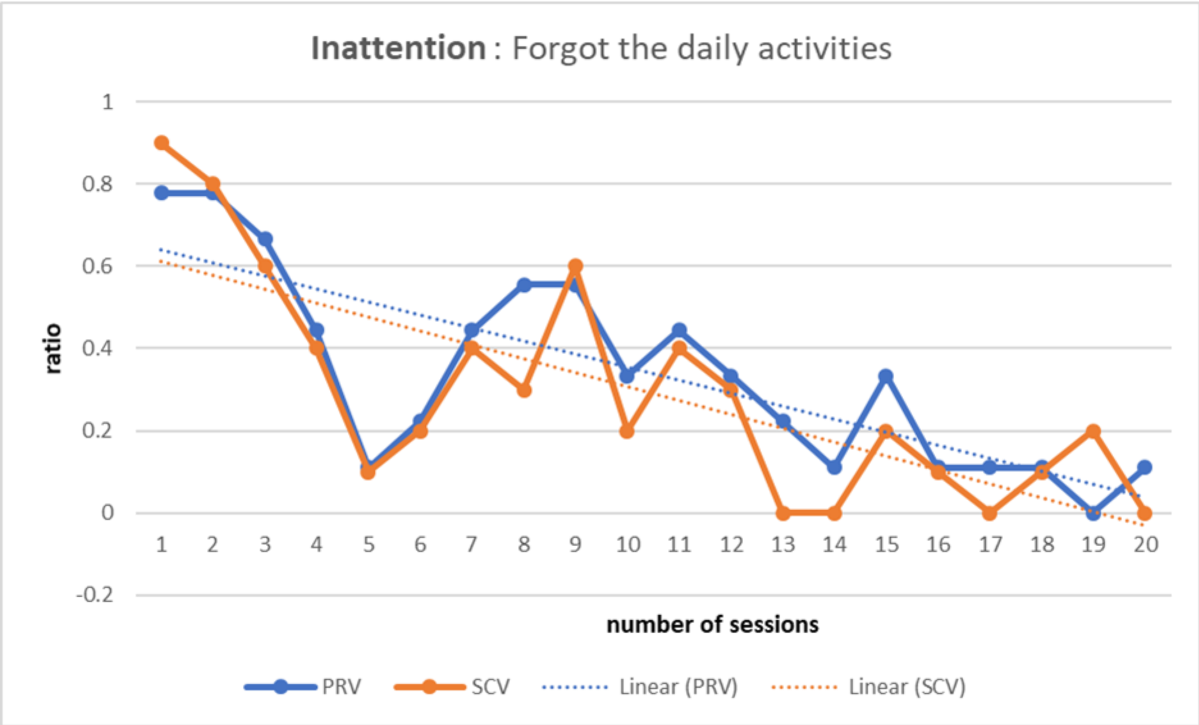


Figure 5.8 Forgets daily activities

Table 5.7 indicates that the Beta is .227 ($p < .05$) for the groups model, which indicates a statistically significant relationship between the groups (SCV and PRV) and the ADHD inattention behaviour, “missing details and the work is inaccurate”. In addition, Table 5.5 shows that Beta is -.798 ($p < .05$) for the number of session models, indicating a statistically significant relationship between the number of sessions and the ADHD inattention behaviour, “missing details and the work is inaccurate”.

Table 5.7 Regression test results for inattention element: ‘Missing details’ and the work is inaccurate

Model	**B**	**Beta**	**t**	**Sig.**
Constant	.649		7.333	.000
Groups	.120	.227	2.472	.018
Number of sessions	-.037	-.798	-8.700	.000

Comparing the regression equation for SCV and PRV for ‘Missing details and the work is inaccurate’:

SCV = .649 - .037 (20)

PRV = .769 - .037 (20)

The regression equation for the inattention item “missing details and the work is inaccurate” shows that the difference between both regression lines along the *y* axis decreases, indicating that both groups (SCV and PRV) showed a decrease in the inattention behaviour, “missing details and the work is inaccurate”. The negative sign in both equations indicates that the two regression lines are going downward, as shown in Figure 5.2. Besides, both constant numbers are close to each other, demonstrating that the regression lines are close together.

Table 5.8 shows that Beta is -.459 (p < .05) for the groups model, indicating a statistically significant relationship between the groups (SCV and PRV) and the ADHD inattention behaviour, “difficulties remaining focused on tasks”. Furthermore, Table 5.8 shows statistically significant results between the number of sessions model and the ADHD inattention behaviour item “difficulties remaining focused on tasks”, where Beta = -.775 (p < .05)

Table 5.8 Regression test results for the inattention element: ‘Difficulties remaining focused on tasks’

Model	**B**	**Beta**	**t**	**Sig.**
Constant	1.025		16.073	.000
Groups	-.225	-.459	-6.435	.000
Number of sessions	-.033	-.775	-10.850	.000

Comparing the regression equation of SCV and PRV for “difficulties remaining focused on tasks”:

SCV = 1.025 - .033 (20)

PRV = .8 - .033 (20)

The regression equation for the inattention item “difficulties remaining focused on tasks” shows that the difference between both regression lines along the y axis decreases, indicating that both groups (SCV and PRV) showed a decrease in the inattention behaviour, “difficulties remaining focused on tasks”. The negative sign in both equations indicates that the two regression lines are going downward, as shown in Figure 5.3. Besides, both constant numbers are close to each other, demonstrating that the regression lines are close together.

Table 5.9 shows that Beta is -.323 (p < .05) for the groups model, indicating a statistically significant relationship between the groups (SCV and PRV) and the ADHD inattention behaviour, “mind seems elsewhere”. In addition, a statistically significant relationship exists between the number of sessions model and the ADHD inattention behaviour item “mind seems elsewhere”, where Beta is -.781 ($p < .05$), as shown in Table 5.10.

Table 5.9 Regression test results for the inattention element: ‘Mind seems elsewhere’

Model	**B**	**Beta**	**t**	**Sig.**
Constant	.864		10.955	.000
Groups	-.159	-.323	-3.675	.001
Number of sessions	-.033	-.781	-8.899	.000

Comparing the regression equation of SCV and PRV for “mind seems elsewhere”:

SCV = .864 - .033 (20)

PRV = .705 - .033 (20)

The regression equation for the inattention item “mind seems elsewhere” shows that the difference between both regression lines in the *y* axis decreases, indicating that both groups (SCV and PRV) showed a decrease in the inattention behaviour, “mind seems elsewhere”. The negative sign in both equations indicates that the two regression lines are going downward, as shown in Figure 5.4. Besides, the constant numbers are close to each other, demonstrating that the regression lines are close together.

Table 5.10 shows that Beta is -.337 ($p < .05$) for the groups model, which suggests a statistically significant relationship between the groups (SCV and PRV) and the ADHD inattention behaviour, “easily distracted”. In addition, Table 5.8 shows a statistically significant relationship between the number of sessions model and the ADHD inattention item “easily distracted”, where Beta = -.791 ($p < .05$).

Table 5.10 Regression test results for the inattention element: ‘Easily distracted’

Model	**B**	**Beta**	**t**	**Sig.**
Constant	1.253		19.090	.000
Groups	-.144	-.337	-4.014	.000
Number of sessions	-.029	-.791	-9.427	.000

Comparing the regression equation of SCV and PRV for “easily distracted”:

SCV = 1.253 - .029 (20) = .673

PRV = 1.109 - .029 (20) = .529

The regression equation for the inattention item “easily distracted” shows that the difference between both regression lines along the *y* axis decreases, indicating that both groups (SCV and PRV) showed a decrease in the inattention behaviour, “easily distracted”. The negative sign in both equations indicates that the two regression lines are going downward, as shown in Figure 5.5. Besides, both constant numbers are close to each, demonstrating that the regression lines are close together.

Table 5.11 shows that Beta is -.019 ($p > .05$) for the groups model, which indicates a statistically insignificant relationship between the groups (SCV and PRV) and the ADHD inattention behaviour, “difficulties organising the task”. However, Table 5.11 shows a statistically significant relationship between the number of sessions model and the ADHD inattention item “difficulties organising the task”, where Beta is -.811 ($p < .05$).

Table 5.11 Regression test results for the inattention element: 'Difficulties organising the task'

Model	**B**	**Beta**	**t**	**Sig.**
Constant	.782		9.333	.000
Groups	-.009	-.019	-.194	.848
Number of sessions	-.034	-.811	-8.444	.000

Comparing the regression equation of SCV and PRV for "difficulties organising the task":

SCV = .782 - .034 (20)

PRV = .773 - .034 (20)

The regression equation for the inattention item "difficulties organising the task" shows that the difference between both regression lines along the *y* axis decreases, indicating that both groups (SCV and PRV) showed a decrease in the inattention behaviour, "difficulties organising the task". The negative sign in both equations indicates that the two regression lines are going downward, as shown in Figure 5.6. Besides, both constant numbers are close to each other, demonstrating that the regression lines are close together.

Table 5.12 shows that Beta is -.197 ($p > .05$) for the groups model, suggesting a statistically insignificant relationship between the groups (SCV and PRV) and the ADHD inattention behaviour, "avoids engagement in tasks". Nevertheless, a statistically significant relationship, as shown in Table 5.12, exists between the number of sessions model and the ADHD inattention item "avoids engagement in tasks", where Beta is -.731 ($p < .05$).

Table 5.12 Regression test results for the inattention element: ‘Avoids engagement in tasks’

Model	**B**	**Beta**	**t**	**Sig.**
Constant	.562		6.658	.000
Groups	-.085	-.197	-1.834	.075
Number of sessions	-.027	-.731	-6.815	.000

Comparing the regression coefficients of SCV and PRV for “avoids engagement in tasks”:

SCV = .562 - .027 (20)

PRV = .477 - .027 (20)

The regression equation for the inattention item “avoids engagement in tasks” shows that the difference between both regression lines along the *y* axis decrease, indicating that both groups (SCV and PRV) showed a decrease in the inattention behaviour, “avoids engagement in tasks”. The negative sign in both equations indicates that the two regression lines are going downward, as shown in Figure 5.7. Besides, both constant numbers are close to each other, demonstrating that the regression lines are close together.

Table 5.13 shows that Beta is .099 ($p > .05$) for the groups model, suggesting a statistically insignificant relationship between the groups (SCV and PRV) and the ADHD inattention behaviour, “forgets daily activities”. Nevertheless, Table 5.11 shows a statistically significant relationship between the number of sessions model and the ADHD inattention item “forgets daily activities”, where Beta is -.731 ($p < .05$).

Table 5.13 Regression test results for the inattention element: ‘Forgets daily activities’

Model	**B**	**Beta**	**T**	**Sig.**
Constant	.585		6.214	.000
Groups	.049	.099	.947	.350
Number of sessions	-.033	-.765	-7.320	.000

Comparing the regression coefficients of SCV and PRV for “forgets daily activities”:

SCV = .585 - .033 (20)

PRV = .634 - .033 (20)

The regression equation for the inattention item “forgets daily activities” shows that the difference between both regression lines along the *y* axis decreases, indicating that both groups (SCV and PRV) showed a decrease in the inattention behaviour, “forgets daily activities”. The negative sign in both equations indicates that the two regression lines are going downward, as illustrated in Figure 5.8. Besides, both constant numbers are close to each other, demonstrating that the regression lines are close together.

5.2.2.2 Findings: Hyperactivity and Impulsivity

Some differences were observed between the PRV and SCV students with respect to different elements of hyperactivity and impulsivity. Figures 5.9 to 5.14 pictorially depict the differences between PRV and SCV students for all elements of hyperactivity and impulsivity. All Figures show a decrease in the appearance of all elements of hyperactivity and impulsivity based on the comparison of the regression line. A similar procedure as in the inattention section was followed to calculate the ratio (see Table 5.14, which provides an example for scoring and calculating the ratio for the element “taps hands or feet”).

Table 5.14 Data for each student: The ‘Taps hands or feet’ factor and calculated ratio

Student PRV	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1	1	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	1	0
2	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	0	0	0
3	1	0	0	1	1	0	1	0	1	1	0	1	1	0	1	0	0	0	0	0
4	1	1	1	1	1	1	0	1	1	0	1	1	1	1	1	1	0	0	0	0
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	0	0	1	0	1	1	1	1	0	0	0	1	0	0	0	0	0
7	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	0	0
8	1	1	1	1	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	0
10	0	0	0	1	1	0	1	1	1	0	1	1	1	1	1	1	1	1	0	0
Ratio	.88	.75	.63	.75	.75	.75	.75	.75	1	.75	.9	.75	.5	.38	.63	.5	.38	.25	.25	.13
Student SCV	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1	1	1	1	1	1	1	1	1	0	0	0	0	1	0	1	0	1	0	0
2	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	0	0	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	0	0
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	0	0	0	1	0	1	1	0	0	0
8	1	1	1	1	1	0	1	1	1	1	1	1	0	1	1	1	1	1	0	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	0	0

10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	0
Ratio	1	1	1	1	1	.9	1	1	1	.9	.8	.8	.6	.8	.6	1	.9	.7	.3	.5

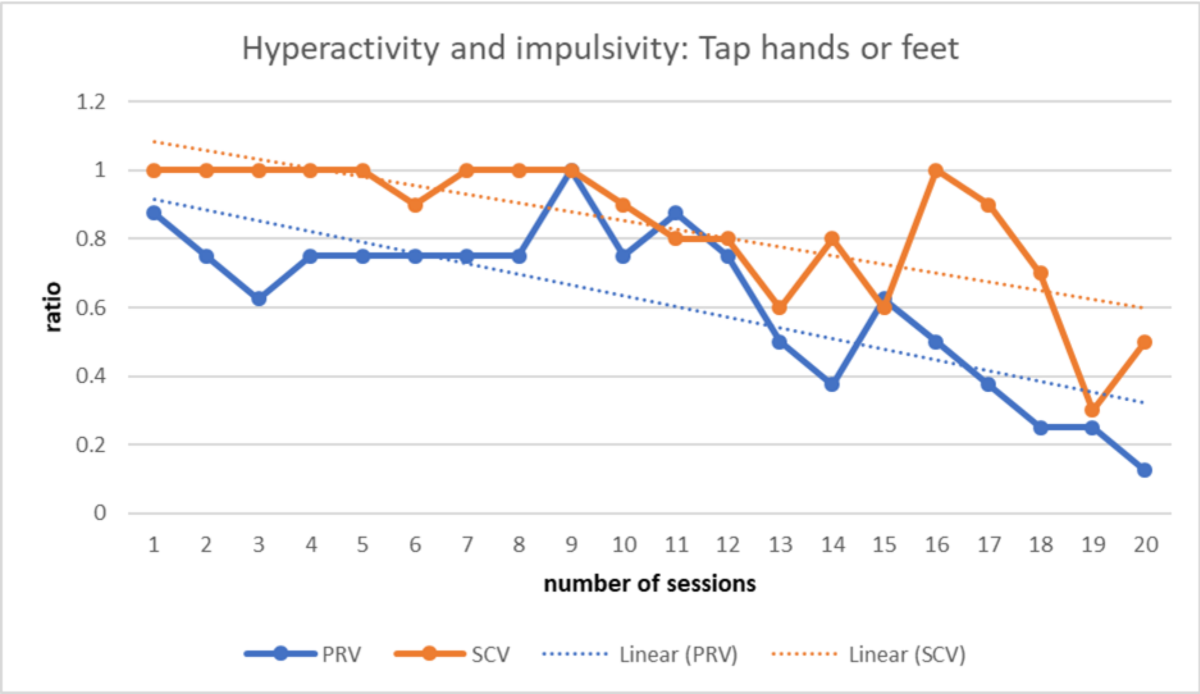


Figure 5.9 Taps hands or feet

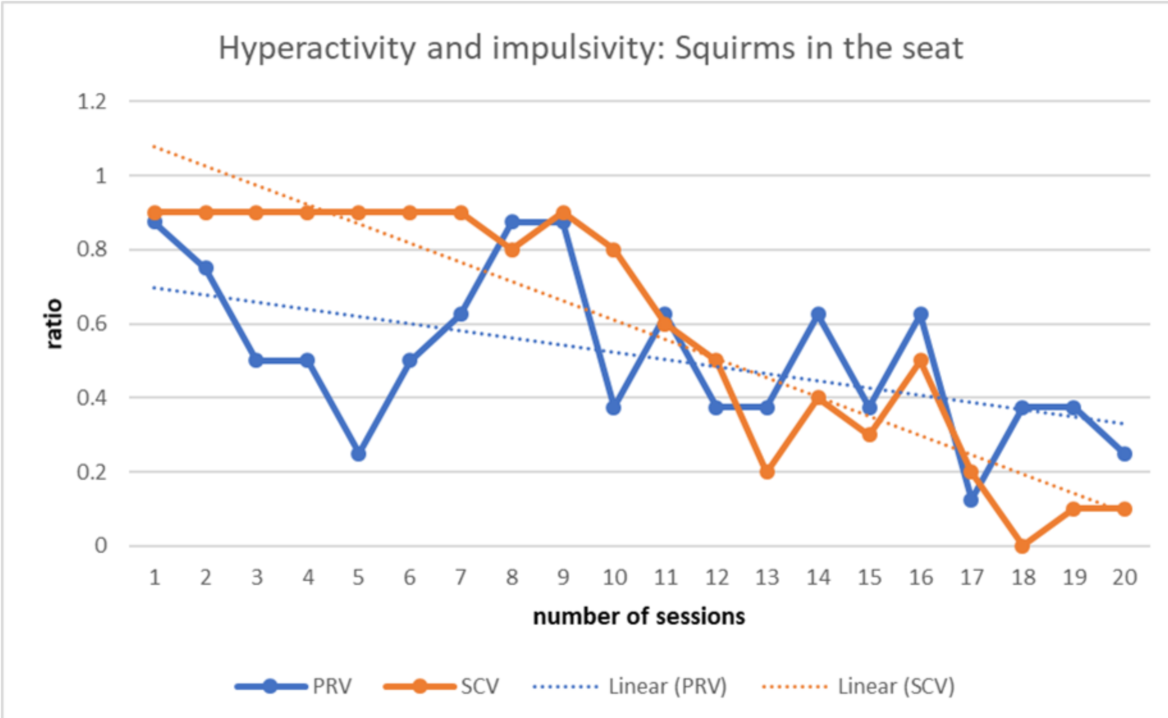


Figure 5.10 Squirms in the seat

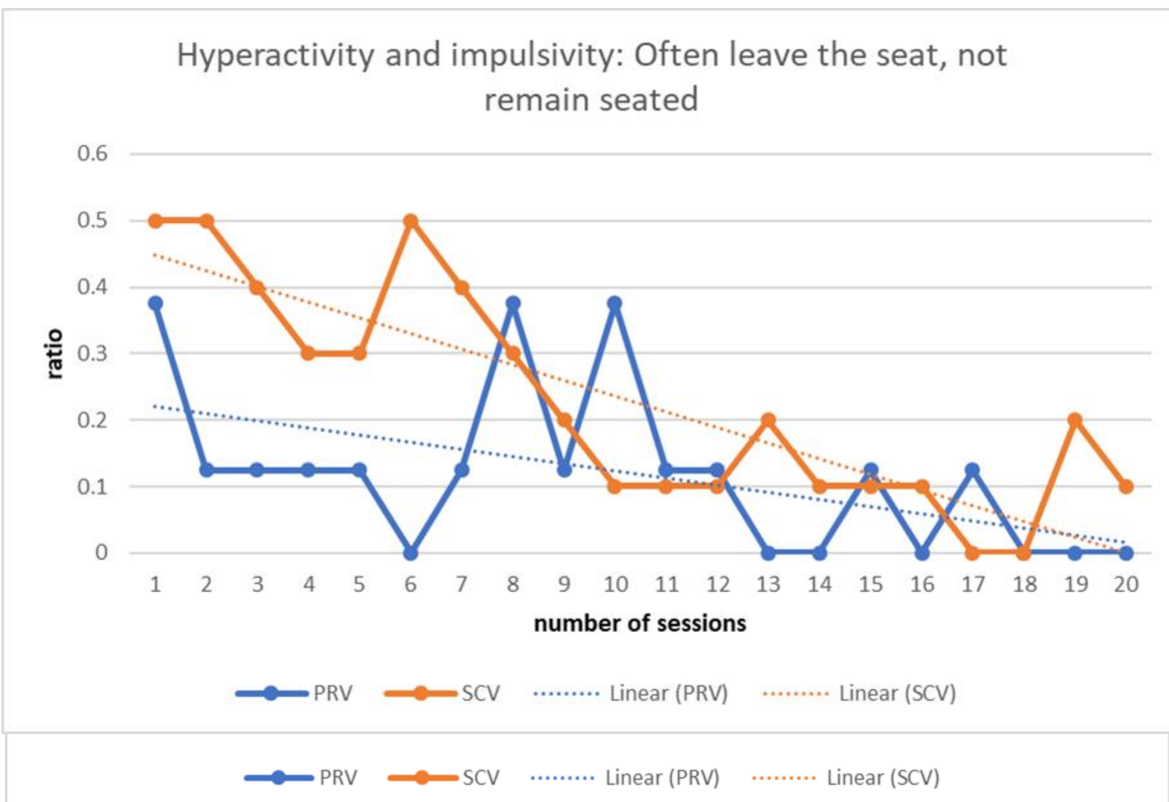


Figure 5.11 Often leaves the seat, does not remain seated

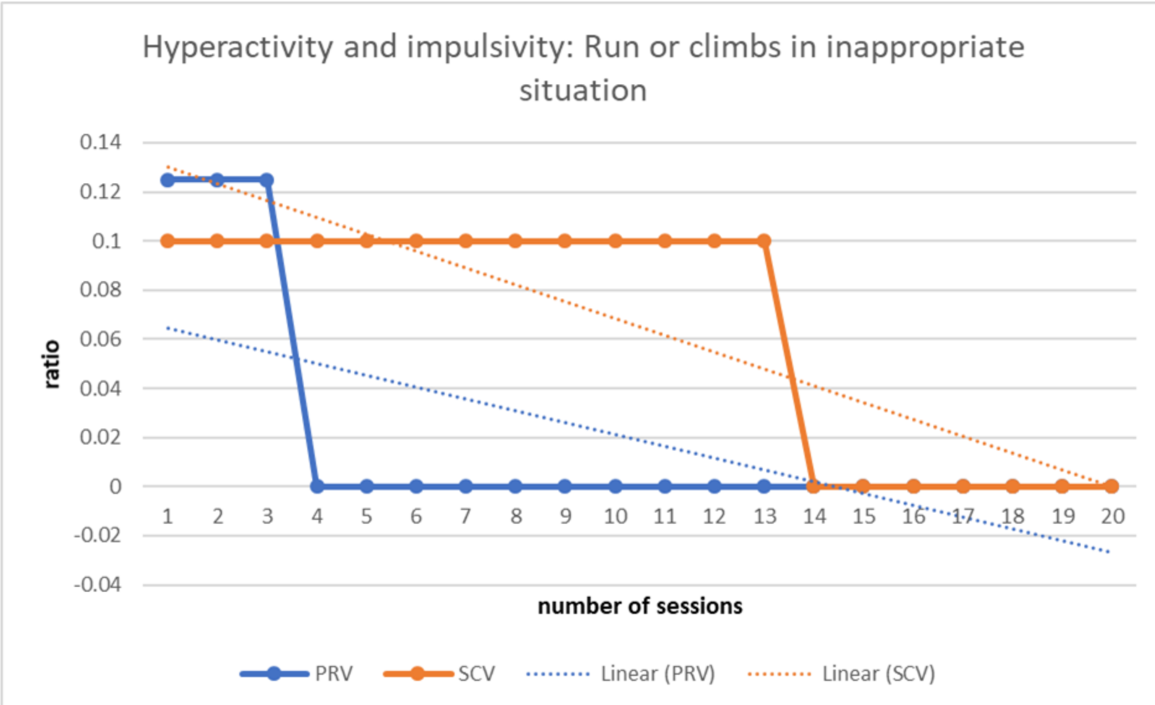


Figure 5.12 Runs or climbs in inappropriate situations

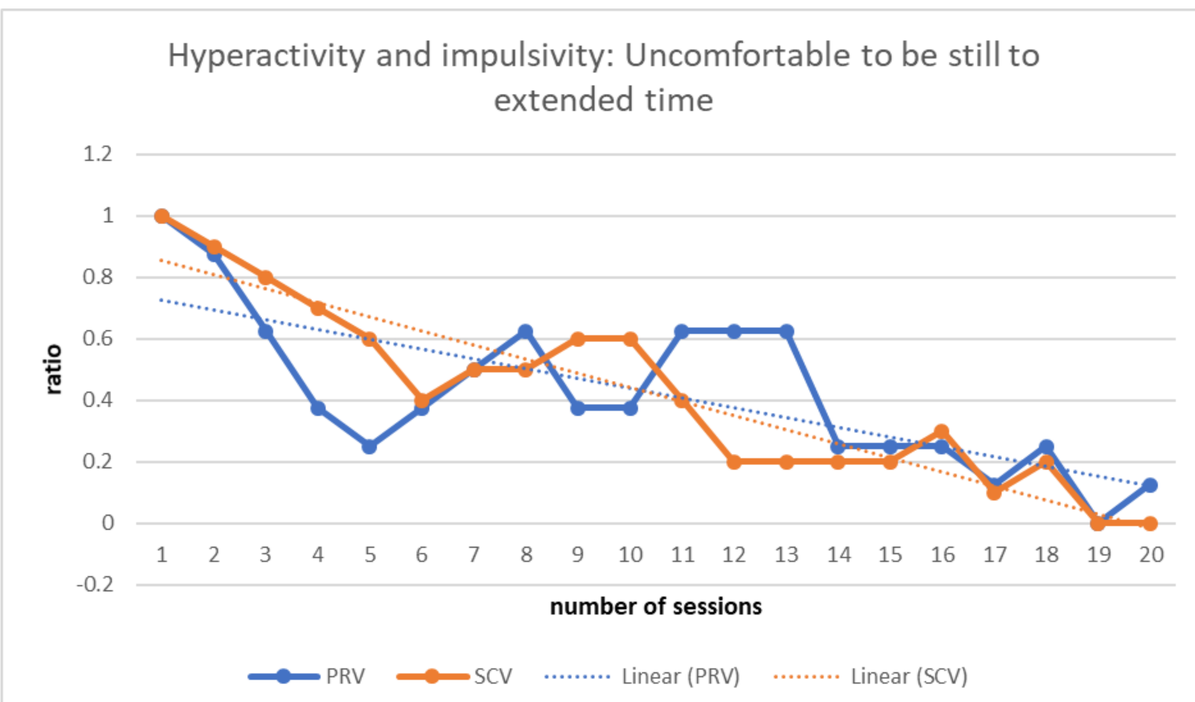


Figure 5.13 Uncomfortable being still for an extended time

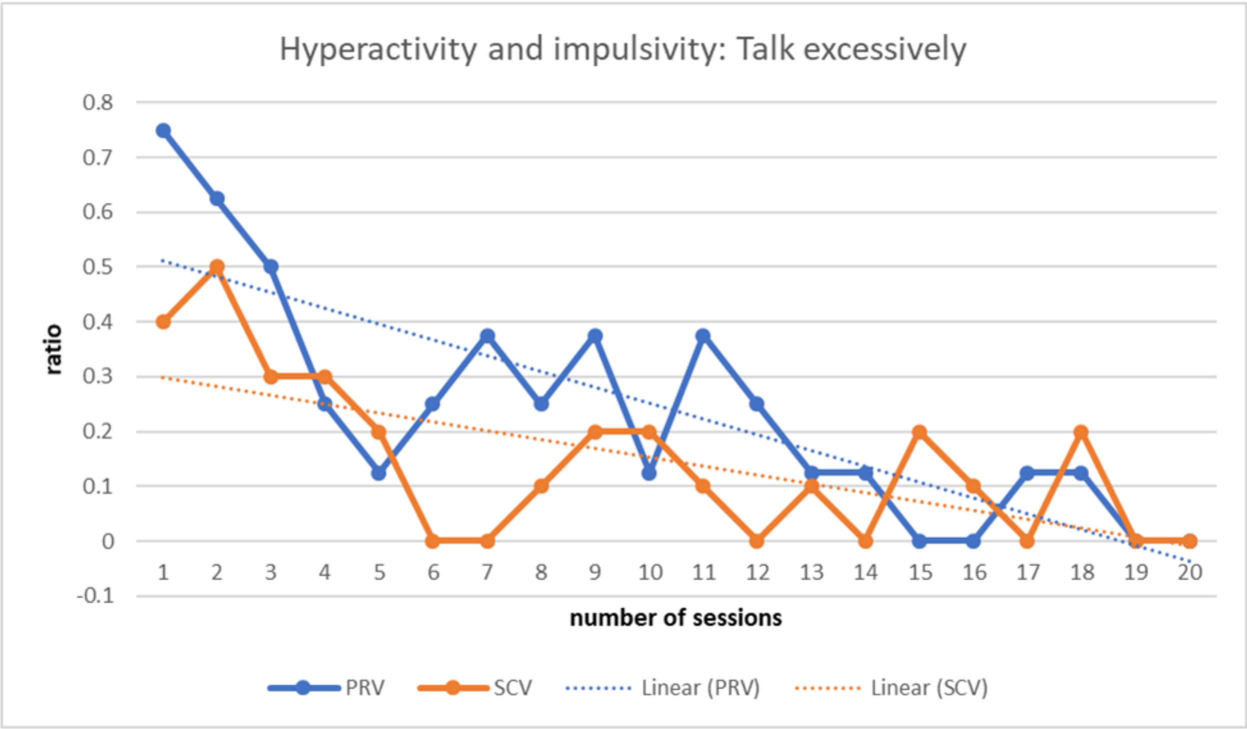


Figure 5.14 Talks excessively

Table 5.15 shows that Beta is -.456 ($p < .05$) for the groups model, suggesting a statistically significant relationship between the groups (SCV and PRV) and the ADHD hyperactivity/impulsivity behaviour, “taps hands or feet”. In addition, Table 5.15 shows that Beta is -.676 ($p < .05$), indicating a statistically significant relationship between the number of sessions model and the ADHD hyperactivity/impulsivity item, “taps hands or feet”.

Table 5.15 Regression test results for the inattention element: ‘Taps hands or feet’

Model	**B**	**Beta**	**t**	**Sig.**
Constant	1.360		16.125	.000
Groups	-.221	-.456	-4.787	.000
Number of sessions	-.028	-.676	-7.094	.000

Comparing the regression equation of SCV and PRV for “taps hands or feet”:

SCV = 1.360 - .028 (20)

PRV = 1.139 - .028 (20)

The regression equation for the hyperactivity/impulsivity item “taps hands or feet” shows that the difference between both regression lines along the *y* axis decreases, indicating that both groups (SCV and PRV) showed a decrease in the hyperactivity/impulsivity behaviour, “taps hands or feet”. The negative sign in both equations indicates that the two regression lines are going downward, as shown in Figure 5.9. Besides, both constant numbers are close to each, indicating that the regression lines are close together.

Table 5.16 shows that Beta is -.131 ($p > .05$) for the groups model, suggesting a statistically insignificant relationship between the groups (SCV and PRV) and the ADHD hyperactivity/impulsivity behaviour, “squirms in the seat”. On the other hand, Table 5.16 shows that Beta is -.740 ($p < .05$), indicating a statistically significant relationship between the number of sessions model and the ADHD hyperactivity/impulsivity item, “squirms in the seat”.

Table 5.16 Regression test results for the inattention element: ‘Squirms in the seat’

Model	**B**	**Beta**	**t**	**Sig.**
Constant	1.032		9.406	.000
Groups	-.073	-.131	-1.210	.234
Number of sessions	-.036	-.740	-6.833	.000

Comparing the regression equation of SCV and PRV for “squirms in the seat”:

SCV = 1.032 - .036 (20)

PRV = .959 - .036 (20)

The regression equation for the hyperactivity/impulsivity item "squirms in the seat" shows that the difference between both regression lines along the *y* axis decreases, indicating that both groups (SCV and PRV) showed a decrease in the hyperactivity/impulsivity behaviour, "squirms in the seat". The negative sign in both equations illustrates that both regression lines going downward, as shown in Figure 5.10. Besides, both constant numbers are close to each, demonstrating that the regression lines are close together.

Table 5.17 shows that Beta is -.349 ($p < .05$) for the groups model, suggesting a statistically significant relationship between the groups (SCV and PRV) and the ADHD hyperactivity/impulsivity behaviour, "often leaves the seat, does not remain seated". In addition, Table 5.17 shows that Beta is -.651 ($p < .05$), indicating a statistically significant relationship between the number of sessions model and the ADHD hyperactivity/impulsivity item, "often leaves the seat, does not remain seated".

Table 5.17 Regression test results for the inattention element: 'Often leaves the seat, does not remain seated'

Model	**B**	**Beta**	**t**	**Sig.**
Constant	.512		8.307	.000
Groups	-.106	-.349	-3.148	.003
Number of sessions	-.017	-.651	-5.867	.000

Comparing the regression equation of SCV and PRV for "often leaves the seat, does not remain seated":

SCV = .512 - .017 (20)

PRV = .406 - .017 (20)

The regression equation for the hyperactivity/impulsivity item “often leaves the seat, does not remain seated” shows that the difference between both regression lines along the *y* axis decreases, indicating that both groups (SCV and PRV) showed a decrease in the hyperactivity/impulsivity behaviour, “often leaves the seat, does not remain seated”. The negative sign in both equations illustrates that both regression lines go downward, as shown in Figure 5.11. Besides, both constant numbers are close to each other, indicating that the regression lines are close together.

Table 5.18 shows that Beta is -.584 ($p < .05$) for the groups model, suggesting a statistically significant relationship between the groups (SCV and PRV) and the ADHD hyperactivity/impulsivity behaviour, “runs or climbs in inappropriate situations”. Furthermore, Table 5.18 shows that Beta is -.263 ($p < .05$), indicating a statistically significant relationship between the number of sessions model and the ADHD hyperactivity/impulsivity item, “runs or climbs in inappropriate situations”.

Table 5.18 Regression test results for the inattention element: ‘Runs or climbs in inappropriate situations’

Model	**B**	**Beta**	**t**	**Sig.**
Constant	1.214		6.198	.000
Groups	-.496	-.584	-4.621	.000
Number of sessions	-.019	-.263	-2.078	.045

Comparing the regression equation of SCV and PRV for “runs or climbs in inappropriate situations”:

SCV = 1.214 - .019 (20)

PRV = .718 - .019 (20)

The regression equation for the hyperactivity/impulsivity item “runs or climbs in inappropriate situations” shows that the difference between both regression lines along the *y* axis decreases, indicating that both groups (SCV and PRV) showed a decrease in the hyperactivity/impulsivity behaviour, “runs or climbs in inappropriate situations”. The negative sign in both equations indicates that the two regression lines are going downward, as shown in Figure 5.12. Besides, both constant numbers are close to each other, demonstrating that the regression lines are close together.

Table 5.19 shows that Beta is .009 ($p > .05$) for the groups model, suggesting a statistically insignificant relationship between the groups (SCV and PRV) and the ADHD hyperactivity/impulsivity behaviour, “uncomfortable being still for an extended time”. However, Table 5.19 shows that Beta is -.837 ($p < .05$), indicating a statistically significant relationship between the number of sessions model and the ADHD hyperactivity/impulsivity item, “uncomfortable being still for an extended time”.

Table 5.19 Regression test results for the inattention element: ‘Uncomfortable being still for an extended time’

Model	**B**	**Beta**	**t**	**Sig.**
Constant	.823		9.345	.000
Groups	.005	.009	.104	.918
Number of sessions	-.039	-.837	-9.288	.000

Comparing the regression equation of SCV and PRV for "uncomfortable being still for an extended time":

SCV = .823 - .039 (20)

PRV = .828 - .039 (20)

The regression equation for the hyperactivity/impulsivity item. "uncomfortable being still for an extended time" shows that the difference between both regression lines along the *y* axis decreases, indicating that both groups (SCV and PRV) showed a decrease in the hyperactivity/impulsivity behaviour, "uncomfortable being still for an extended time". The negative sign in both equations indicates that the two regression lines are going downward, as shown in Figure 5.13. Besides, both constant numbers are close to each other, demonstrating that the regression lines are close together.

Table 5.20 shows that Beta is .253 ($p < .05$) for the groups model, suggesting a statistically significant relationship between the groups (SCV and PRV) and the ADHD hyperactivity/impulsivity behaviour, "talks excessively". It also shows that Beta is -.709 ($p < .05$), indicating a statistically significant relationship between the number of sessions model and the ADHD hyperactivity/impulsivity item, "talks excessively".

Table 5.20 Regression test results for the inattention element: 'Talks excessively'

Model	**B**	**Beta**	**t**	**Sig.**
Constant	.288		3.995	.000
Groups	.092	.253	2.338	.025
Number of sessions	-.022	-.709	-6.548	.000

Comparing the regression equation of SCV and PRV for “talks excessively”:

SCV = .288 - .022 (20)

PRV = .35 - .022 (20)

The regression equation for the hyperactivity/impulsivity item “talks excessively” shows that the difference between both regression lines along the *y* axis decreases, indicating that both groups (SCV and PRV) showed a decrease in the hyperactivity/impulsivity behaviour “talks excessively”. The negative sign in both equations indicates that the two regression lines are going downward, as shown in Figure 5.14. Besides, both constant numbers are close to each other, demonstrating that the regression lines are close together.

5.3 Discussion

It was believed that remaining focused and decreased ADHD behaviours can be affected by using SCV or PRV. Willcutt et al. (2005), and Etnier and Chang (2009) mention that remaining focused could be linked with weak EF in individuals with ADHD. This affects their working memory, thereby preventing response control and increasing impulsivity, where executive function “underl[ies] cognitive functions for purposeful, goal-directed behaviour” (Etnier & Chang, 2009, p.470). In addition, remaining focused can reflect self-control, attention, planning, reasoning, and working memory skills (Hughes & Graham, 2002; Brown, 2006), suggesting that these factors are why students with ADHD show low academic achievement, anxiety, aggression, desperation, and poor peer and family relationships, which have a direct effect on their behaviour (Barkley, 1997; Rapport et al., 2013; Alloway & Cockcroft, 2014).

Arguably, the current study might have an impact on ADHD students' EF; thus, all participants in the current study showed an improvement in their behaviour (as discussed in this chapter) and their academic achievement in solving mathematical word problems (see Chapter 4). Therefore, the current study closely examined how SCV and PRV affected directing and developing ADHD behaviours by remaining focused while solving mathematical word problems. The use of the foregoing linear regression test demonstrated that both the SCV and PRV groups showed similar improvements in their ADHD behaviour, with no differences with respect to any of the observation elements for inattention, hyperactivity/impulsivity. This answers the second research question (*To what extent do PRV and SCV help students with ADHD remain focused while solving mathematical word problems?*) and demonstrates that the use of both SCV and PRV affected ADHD students, with both (SCV and PRV) having the primary goal of focusing, maintaining their attention, and directing their behaviour.

One reason for the current result that both SCV and PRV groups showed development in their behaviours may be because the current study did not take into account grouping the students with ADHD, based on their individual differences. Neither did it consider other individual factors that might have directly influenced students' behaviours and reactions, such as relationships, anxiety, and desperation, which can affect the data and the results of the current study observation.

Further, the ability to notice changes in behaviour depends on how clear that behaviour is, which depends on the type of ADHD. In line with this point, Cardo, Servera and Llobera (2007) studied 29,435 children aged 6 to 12 years from 215 schools in Majorca and reported that the estimated prevalence of ADHD was 4.57% and comprised the following types: combined ADHD type 2.25%, hyperactivity/impulsivity type 1.26%, and inattention type 1.06%. Fewer behaviour changes related to inattention might be noticed. Indeed, the most problematic observational elements were in inattention (for example, “missing details and the work is inaccurate” and “forgets daily activities”). Thus, taking notes was necessary to make the observations more valid.

However, Cerrillo-Urbina, García-Hermoso, Martínez-Vizcaíno, Pardo-Guijarro, Ruiz-Hermosa and Sánchez-López (2018) obtained different results. They studied the prevalence of different ADHD types among 1,604 children aged 4 to 6 years in Spain. Their study revealed that the prevalence of ADHD was 5.4%, comprising inattention type 2.6%, hyperactivity/impulsivity type 1.5%, and combined symptoms type 1.3%. Although the age ranges differed between the two studies, the current research suggests that the combined symptoms of ADHD in students are more challenging to identify than other symptoms. A student with combined symptoms can show all ADHD behaviours (inattention, hyperactivity, and impulsivity) at once, making it challenging to observe this type of ADHD student. Consequently, watching the intervention session videos more than once was essential in order to ensure that all behaviour elements were correctly identified. Therefore, the results might be more concise and reliable if each ADHD type had been grouped and studied separately, as noticing the ADHD behaviour symptoms is crucial depending on the type of ADHD that students have.

5.4 Summary

The use of visualisation and its impact on ADHD behaviour were investigated through an observation study involving 20 ADHD students. These observations helped answer the second research question (*To what extent do PRV and SCV help students with ADHD remain focused while solving mathematical word problems?*). Linear regression tests were used to understand how the intervention tool (SCV) helped keep ADHD students focused while solving mathematics word problems compared to using PRV. The results revealed a statistically significant relationship between PRV and SCV groups and the number of sessions in regard to inattention, hyperactivity, and impulsivity items. It can be concluded that there is no advantage to using SCV over PRV with ADHD students to keep them focused while solving mathematical word problems.

CHAPTER 6: ANALYSIS AND FINDINGS FOR RESEARCH QUESTION THREE

6.1 Introduction

This chapter discusses the findings for students' perceptions of using SCV and PRV and the effect of these visualisations on their mathematical word problem-solving ability, in order to answer the third research question (*What are ADHD children's perceptions of using PRV and SCV to solve mathematical word problems?*). The data collection procedure, translation mechanism, and analysis will be discussed in detail. The process of developing the themes and codes will then be highlighted, and the findings critically discussed.

6.2 Generating Codes and Themes

After the interview data had been prepared through transcription and translation (as described in subsection 3.4.2.2.2), qualitative analysis was carried out by generating codes and themes. The coding process involved moving from taking notes and recording memories, to labelling, classifying, and interpreting the transcript data (Creswell & Poth, 2017; Creswell & Guetterman, 2018). The data were analysed using a constant comparative analysis approach (see subsections 3.6.2.1 and 3.6.2.2). Miles et al.'s (2014) bottom-up approach was used to analyse the interview data by first, developing the codes and then grouping them into sub-themes, and the sub-themes into themes.

6.3 Findings and Discussion

As Figure 6.1 shows, the analysis yielded two themes, each made up of two sub-themes. In turn, each sub-theme was made up of a number of codes. The following sections will discuss these themes, sub-themes and codes in detail. The same student labelling system as in sub-section 3.4.2.2.2 Procedure for Collecting the Semi-structured Interview Data was applied for the interview analysis.

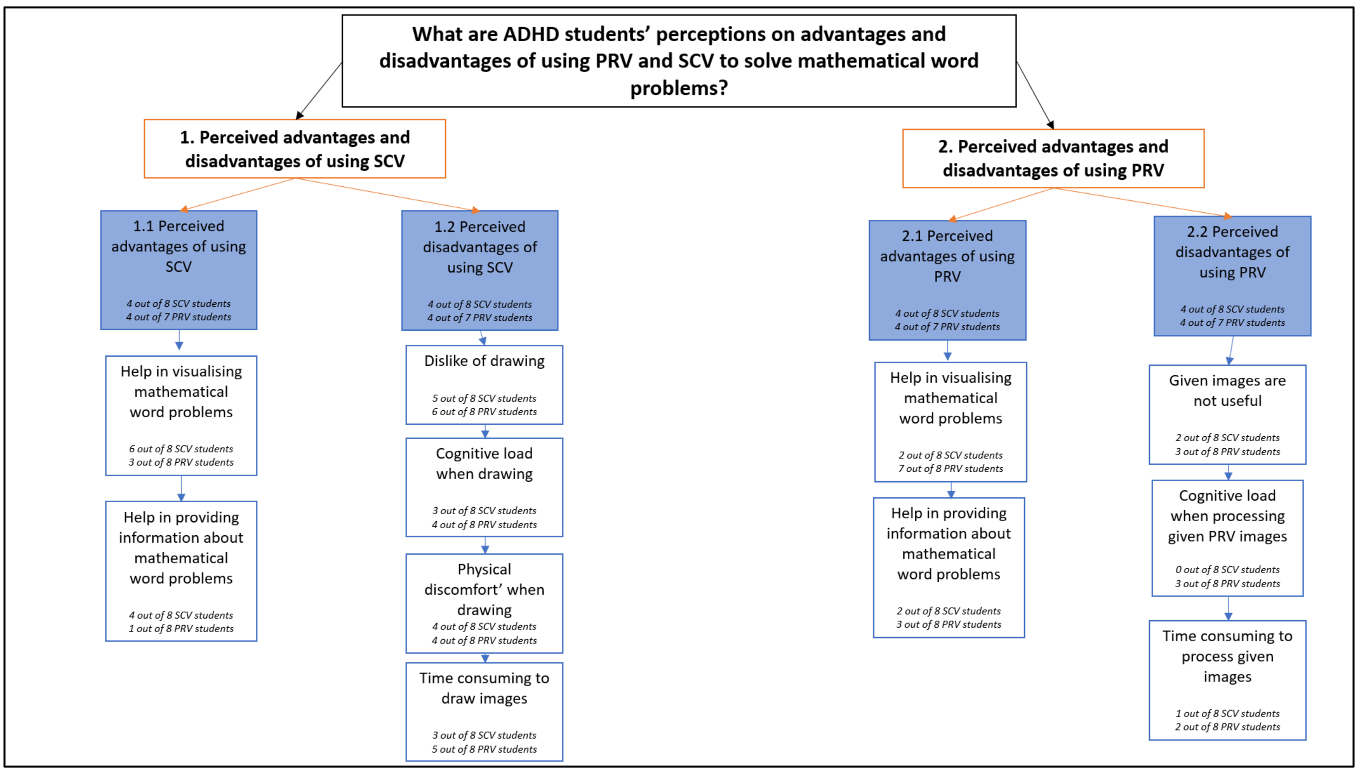


Figure 6.1 Themes and codes

6.3.1 Theme 1: Perceived Advantages and Disadvantages of using SCV

This theme concerns the SCV and PRV students' perceptions of the advantages and disadvantages of using SCV, whereby the first sub-theme focuses on the advantages and the second sub-theme focuses on the disadvantages (see Figure 6.1). The first sub-theme (perceived advantages) has two codes: help in visualising mathematical word problems and help in providing information about mathematical word problems. The second sub-theme (perceived disadvantages) has four codes: dislike of drawing, cognitive load when drawing, hurt when drawing, and time-consuming activity of drawing images.

6.3.1.1 Sub-theme 1: Perceived Advantages of Using SCV

6.3.1.1.1 Help in Visualising Mathematical Word Problems

This code concerns the students' perceptions of using SCV to help visualise mathematical word problems, in order to solve them—specifically, to help translate words into images. The students' responses in relation to this code were collected by asking more in-depth questions about why they used SCV to help solve mathematical word problems, especially during the weekly tests and in the post-test, and how using the SCV had helped them find solutions. If the students did not use SCV in the weekly tests or post-test, but did so in the initial interview question, the interviewer asked for clarification of using SCV.

Six SCV and three PRV students responded to this code. From the interview transcripts, most of the students' perceptions used the word "see" and "in front of my eyes" to express that using the SCV while solving mathematical word problems helped them visualise the problem or provide all the problem's information visually (see the students' responses in Appendix 4). For example, Student 1-B-SCV highlighted: "I have to draw to see the problem"; he also added, "Yes, so everything will be in front of my eyes". Student 2-B-SCV's response was: "While I am drawing, I can see everything in the problem. For example, I can draw four cars and each car has four passengers; then I can count them all." Furthermore, Student 3-B-SCV added, "I was using circles as sets [the student tried to use SCV by drawing circles as sets for the question in the beginning of the interview], this made everything visible for me to solve the problem". He went on to explain, "By drawing circles [the student tried to use SCV by drawing circles as sets for the question in the beginning of the interview, which was: "One taxi can load four passengers, how many passengers can six taxis load?"], I can see everything clearly, so I can solve correctly". Likewise, Student 7-G-SCV stated; "I used some drawing for the difficult problems because drawing can provide all the problem information in front of your eyes."

The PRV students also gave similar responses. For example, Student 3-B-PRV said, "While I am solving the problem, I draw a square [the student tried to use SCV by drawing squares as sets for the question in the beginning of the interview; see above] and read to find the solution". Student 6-G-PRV reported that "I can see the problem by using drawing [SCV]", and Student 7-G-PRV highlighted: "drawing [SCV] was clear for me by seeing the problem's information."

6.3.1.1.2 Help in Providing Information about Mathematical Word Problems

This code concerns students' perception of using SCV to gather information to solve mathematical word problems. As using visualisation was the key aspect that helped students underline the information in these problems, their responses under this code are linked to the code, 'help in visualising mathematical word problems'. The word 'information' in this context refers to the word problem input, which the student must extract from the mathematical word problem to solve them. Most of questions under this code inquired why the students thought SCV was more useful than PRV; why they preferred using SCV over PRV, and why they wanted to use SCV. Only four out of the eight SCV students and one out of the eight PRV students responded to this code.

For example, Student 3-B-SCV stated: “Let us suppose that once, I did not have a picture [PRV], drawing would then be better, where I can provide myself with all the information that I need to solve the problem.” He added: “the drawing [SCV] was clear by providing all information about the problem.” Similar perceptions can be found in Student 6-G-SCV’s responses, which included: “Yes, I know how to solve but not well, but by using drawing [SCV], all information [the given information from the word problem] is there.” Student 7-G-SCV also responded in the same vein: “I used some drawing [SCV] for the difficult problems because drawing [SCV] can provide all the problem information”, and Student 8-G-SCV emphasised: “I solve it by using drawing [SCV], because it can make the problems’ information accessible.” Finally, the only PRV student who used her fingers to count and solve problems, Student 7-G-PRV, responded: “drawing [SCV] is clearer than solving by my fingers, because all information is provided.”

As only five students highlighted the word ‘information’ in their responses to questions under the code: help in providing information about mathematical word problems, it could be argued that few students found that SCV helped them extract the necessary information from mathematical word problems in order to solve them. Nevertheless, more SCV than PRV students thought that using SCV helped them obtain all the necessary information from the word problems. In fact, only one PRV student supported this idea. Although there were only a few responses from the students, this code provided data on the advantages of using SCV to solve mathematical word problems.

6.3.1.2 Sub-theme 2: Perceived Disadvantages of Using SCV

6.3.1.2.1 Dislike of Drawing

This code concerns the SCV and PRV students' perceptions of their dislike of using SCV. The analysis of the interview data revealed that more PRV than SCV students appeared to dislike using SCV. In total, 11 students responded to this code (five out of eight SCV students and six out of eight PRV students). The answers related to this code were elicited during the interviews by asking the students which tool (SCV or PRV) they preferred to use and their reasons for not applying SCV when solving the given word problem. Interestingly, more than half of the interviewed SCV students responded that they did not like using SCV and preferred using PRV to solve mathematical word problems, because it was easier than creating their own SCV visualisation. The PRV students responded to this code in a similar manner and only used SCV for one session. Most of the SCV students disliked using SCV, because they did not find it as easy as using PRV. For example, Student 5-G-SCV stated: "I prefer seeing pictures [PRV] and solving, because it is easier than drawing [SCV]." Student 8-G-SCV also claimed: "it is easier than drawing [SCV]."

Similar perceptions were gathered from the PRV students. Some referred to their lack of knowledge of creating SCV visualisation based on word problems. For example, Student 2-B-PRV commented: "I did not know how to draw [using SCV], so I prefer not to draw [using SCV]." Moreover, Student 4-B-SCV explained: "I could not solve it by drawing [SCV], because I did not get any training about using drawing [SCV] to solve mathematical word problems." Other PRV students' perceptions were more general: "I did not like drawing [SCV] to solve mathematical word problems" (for additional perceptions, see Appendix 4).

6.3.1.2.2 Cognitive Load When Drawing

This code concerns students' perception of the cognitive load as a result of using SCV to solve mathematical word problems. (As noted in the Literature Review chapter, cognitive load refers to the working memory capacity to deal with a new learning task which affects the learning outcomes; Kirschner, Sweller, Kirschner, & Zambrano, 2018; Sepp, Howard, Tindall-Ford, Agostinho, & Paas, 2019). Seven students (three out of eight SCV students and four out of eight PRV students) responded that using SCV required a lot of thinking and mental effort, and sometimes it caused confusion.

Some of the students' perceptions of this code might be due to their lack of knowledge about using SCV, which caused cognitive load while trying to apply it, especially for those in the PRV group. The three SCV students' perceptions of the cognitive load when using SCV indicated that SCV required significant mental effort to solve mathematical word problems. For example, Student 5-G-SCV said, "In drawing [using SCV], I have to do everything by myself and this takes too much time and mental effort compared with using pictures [PRV]". Meanwhile, Student 6-G-SCV stated: "drawing [SCV] needs a lot of thinking, this gives me a headache", and Student 8-G-SCV declared, "by using pictures [PRV], I can't get nervous or confused because the drawing [SCV] is there, so I do not need to think about what to draw or what to do".

Conversely, the PRV students attributed their perception of cognitive load when using SCV to their lack of knowledge about using SCV (see Appendix 4). For example, Student 1-B-PRV explained: "I do not have the experience in using drawing [SCV], so in order to do the drawing [SCV] I need to think how." Student 2-B-PRV likewise reported: "I do not know how to use it and it required a lot of thinking about what to draw and how to solve the problems." Similarly, Student

3-B-PRV said, "it was difficult, it required a deep thinking and I did not know what I have to do exactly". Finally, Student 6-G-PRV indicated: "I never used drawing [SCV] before, therefore, I did not have the experience to draw in solving mathematics word problems, so I need to squeeze my brain in order to do one drawing for one problem."

6.3.1.2.3 Physical Discomfort When Drawing

This code concerns students' perception of the physical discomfort caused when using SCV. Words such as "hurting arms", "headache", and "feeling tired" were found in the interview transcripts. According to the analysis, eight students (four out of eight SCV students and four out eight PRV students) felt that using SCV might cause them pain. The perceptions for this code were elicited by asking why they might not use SCV to solve mathematical word problems, or whether or not they would adopt this method and their reasons why.

Analysing the interview data revealed that some students had no problems with using SCV to solve mathematical word problems, but it could be an issue for them if they did too many word problems. For example, Students 4-B-SCV's, 1-B-PRV's, 6-G-SCV's, 2-B-PRV's, 8-G-SCV's, and 5-G-PRV's perceptions were that too many questions to produce drawings for could cause different types of pain, such as hand pain, fatigue and headaches (see Appendix 4). Student 2-B-SCV's response was about getting tired, "because by using pictures [PRV], I will not get as tired as doing the drawing [SCV]". This view was shared by Student 1-B-PRV. Student 6-G-SCV highlighted another perception of hurting hands: "A lot of questions to be drawn hurts my hands….."; similar perceptions were identified by Students 5-G-PRV and 1-B-PRV. In addition, some students' perceptions were about having a headache while using SCV. Student 4-B-SCV indicated: "drawing [SCV] too many pictures sometimes gives me a headache." Student 6-G-SCV also reported: “too much drawing [SCV] can give me a headache.” Furthermore, Student 8-G-SCV said, “sometimes when I did too much drawing [SCV] I have headaches”. Student 2-B-PRV also declared, “it [SCV] can give me headache when I tried to do it [SCV] because there were too many problems to be solved”.

In summary, half of the interviewed students appeared to believe that using SCV could cause physical discomfort, especially when solving too many mathematical word problems. As noted in the discussion thus far, three types of physical discomfort were identified in the students’ perceptions: getting tired while using SCV to solve mathematical word problems, doing too much SCV can hurt one’s hands, and using SCV could cause headaches.

6.3.1.2.4 Perception of It Being Time-consuming to Draw Images

This code concerns students’ perception that SCV drawing to solve mathematical word problems could be time-consuming. Three out of eight students in the SCV group and five out of eight students in the PRV group responded to questions relating to this code. Therefore, time appeared to be an issue that could affect students’ ability to solve mathematical word problems. Student 4-B-SCV said, “I did not finish all the questions. I needed more time to draw them all”; he added that he preferred using PRV over SCV because he found using PRV more accessible and less time-consuming than SCV, because “using pictures [PRV] is easy to understand and it did not require a lot of time like drawing [SCV]”.

As SCV is time-consuming, some students did not benefit from using it to solve mathematical word problems; instead, they preferred to count mentally or use their hands, rather than creating a drawing, as justified in some of the interviews. For example, Student 1-B-PRV said, “In the beginning, I thought about using drawing but later I told myself counting mentally is better because drawing [SCV] might take time”. Similarly, Student 2-B-PRV stated: “Yes, I prefer to count mentally instead of doing drawing [SCV] because drawing [SCV] takes time.” Student 3-B-PRV also declared, “Yes, counting on my hand is easier and faster than doing a drawing [SCV]”.

Additionally, as the SCV students practised using PRV for one session, some of these students in the SCV groups preferred to use PRV, rather than SCV, because they thought that PRV was easier than SCV and did not take much time. For example, Student 4-B-SCV said, “Because using pictures [PRV] is easier than drawing [SCV] in getting the answer and faster”. Student 8-G-PRV also reported that “pictures [PRV] did not take time in thinking about what to draw”.

In summary, it could be argued that using SCV is time-consuming. Accordingly, the students’ perceptions addressed alternatives to SCV (for example, mental counting, counting on fingers and using PRV images), as these can be easier and faster than using SCV. This point could explain why the intervention was not long-lasting through the delayed test, since the students found SCV to be time-consuming and alternatives were better.

6.3.2 Theme 2: Perceived Advantages and Disadvantages of Using PRV

This theme concerns students’ perceptions of the advantages and disadvantages of using PRV (see Figure 6.1). The first sub-theme (perceived advantages) has two codes: help in visualising mathematical word problems, and help in providing information about mathematical word problems. Meanwhile, the second sub-theme (perceived disadvantages) has three codes: given images are not useful, cognitive load when processing given PRV images, and time-consuming to process given images. The students in both groups were invited to answer questions related to this theme. It is worth noting that only one SCV student used PRV in the reversal session.

6.3.2.1 Sub-theme 1: Perceived Advantages of Using PRV

6.3.2.1.1 Help in Visualising Mathematical Word Problems

This code concerns students' perception of using PRV to help them visualise mathematical word problems. The analysis of the interview data found that some students thought using PRV helped develop their ability to visualise word problems. In PRV, words were translated into a visual representation through the image that accompanied the problem. Nine students responded to this code (two out of eight SCV students and seven out of eight PRV students). Thus, more PRV than SCV students responded to this code. These perceptions were elicited by asking the students why they preferred to use PRV, or how PRV benefited them when solving mathematical word problems.

The interview transcripts indicated that most of the SCV and PRV students' perceptions highlighted key words, such as "see" and "in front of my eyes", to suggest how using PRV helped them solve mathematical word problems through visualisation (see Appendix 4). Such key words were found in the interview data. Student 8-G-SCV said: "everything is in front of your eyes, this makes it easier for me to see all the problem information", whereas Student 2-B-PRV stated: "I can see the problem through the pictures [PRV] clearly" (for further perceptions of this code, see Appendix 4.)

However, some PRV students were very precise about how PRV as a visual representation of a mathematical word problem helped them visualise the words in the problem by developing their mental image. These students used the words “imagined” or “imagine” to show the development of their mental image using PRV. For example, Student 1-B-PRV said, “I imagined six cars then I put four persons, then I count them four times” [the student was talking about the question at the beginning of the interview, which was “One taxi can load four passengers. How many passengers can six taxis load?”]. Meanwhile, Student 2-B-PRV stated: “I can think better now by imagining what the problem looks like. Similarly, Student 4-B-PRV said, “I think they need the total [referring to the question at the beginning of the interview], so I imagined that my fingers were the taxis and then I started to add them all”; he added, “Yes, I have a picture [PRV] in my mind and my fingers are the taxis”.

The majority of the PRV students’ perceptions highlighted that using PRV helped them see the problem and develop their imagination (or visualisation), as previously discussed (similar to what was discussed in relation to the sub-theme, perceived advantages of using SCV). Finally, based on the students’ perceptions, both the SCV and PRV groups benefited from using SCV and PRV to visualise mathematical word problems, which provides a reason for the non-significant results in the quantitative phase of the intervention (see Chapter 4).

6.3.2.1.1 Help in Providing Information about Mathematical Word Problems

This code concerns students’ perceptions of how PRV could help them extract the necessary information from mathematical word problems. Only five students responded to this code (two out of eight SCV students and three out of eight PRV students). The students’ perceptions were elicited by asking them why they thought that being given pictures (PRV) was better than creating their own drawings (SCV); why they preferred using PRV over using SCV to solve mathematical word problems, and why they might prefer to use PRV to solve mathematical word problems.

Among the PRV students, Student 1-B-PRV responded: “It helped to understand the picture [PRV] first and provide me with the important information [data] about the problems.” Student 4-B-PRV similarly highlighted: “when you give me the pictures [PRV], I looked and then I started to think about how to solve the problem through the picture’s [PRV] information.” Meanwhile, Student 7-G-PRV stated: “[the] pictures [PRV] were clear by providing all the information that I needed to find the answer.”

Further support for using PRV as a helpful tool to extract the necessary information to solve mathematical word problems was found in the SCV students’ interview data. These students’ perceptions showed that using PRV can provide the information that they need without them having to create their own drawing (SCV). For example, Student 4-B-SCV reported: “pictures [PRV] can give me all information that I need without drawing [SCV]” and Student 6-G-SCV said, “pictures [PRV] can provide all the problem information clearly”.

6.3.2.2 Sub-theme 2: Perceived Disadvantages of Using PRV

<u>6.3.2.2.1 Given Images Are Not Useful</u>

This code concerns students’ perceptions of how given images (PRV) are not useful. The students’ perceptions of this code were elicited by asking them about their decision not to adopt PRV in future, or why they would not advise their teacher or friend to use it or apply it in class. Two out of eight SCV students and three out of eight PRV students responded to questions relating to this code.

The SCV students highlighted that PRV might not be useful, because, in some cases, the PRV images did not cover the mathematical word problems clearly. Thus, they preferred creating their own images (SCV), since they could then include all the information that they required, but which might not be provided in a PRV. For example, Student 1-B-SCV stated: "It is easier for me to do everything by myself. Using picture [PRV] might not have everything I need." Likewise, Student 3-B-SCV proposed: "Let us suppose that once, I did not have a picture; therefore drawing [SCV] would be better, where I could provide myself with all the information that I needed to solve the problem."

Other perceptions amongst the PRV students highlighted the lack of clarity of the images provided, as the main reason for not using PRV to solve mathematical word problems. For example, Student 5-G-PRV said, "I did not recognize what the picture [PRV] was about"; she added: "some pictures [PRV] were not clear for me." This perception resonates with that of Student 3-B-SCV, who concluded: "I can solve it by using pictures [PRV], but may be wrong, because the pictures [PRV] were not clear to me."

In summary, only a few students believed that PRV was not useful for solving mathematical word problems. This point explained why some PRV students created their own visualisations (SCV) in the intervention tests, and why they preferred to use SCV over PRV.

6.3.2.2.2 Cognitive Load When Processing Given PRV Images

This code concerns students' perceptions of the cognitive load that might be caused by using PRV to solve mathematical word problems. The interview data indicated that only three out of eight PRV students responded to this code, while no SCV students responded.

The students' responses in relation to this code were elicited by asking them to provide more clarification of the method that they wished to use in future. If they replied that they would not use

PRV, because it is not useful, further questions were asked to clarify why they thought this, and to specify the ways in which PRV was not useful for them. The students who responded to this code highlighted that it was not always possible to understand PRV images, because PRV requires a great deal of thought about the image content, in order to understand them.

For example, Student 4-B-PRV commented, “I did not like it, because it required a lot of effort in looking and thinking about the picture [PRV] and what information was there and if this information was useful or not”. Meanwhile, Student 5-G-PRV said, “I did not recognise what the picture [PRV] was about. Sometimes pictures [PRV] require a lot of thinking”. Furthermore, Student 6-G-PRV stated: “it was difficult to look at a picture [PRV] and try to understand it”; she added: “I did not understand many of the pictures [PRV]. I needed to think a lot about the content of the pictures [PRV].” From these responses, it may be concluded that the lack of clarity in the given images (PRV) could cause cognitive load when trying to understand them.

6.3.2.2.3 Time-consuming to Process Given Images

This code concerns students’ perceptions of given images (PRV) taking time to solve mathematical word problems. Only three students (one out of eight students in the SCV group and two out of eight students in the PRV group) responded to questions about this code; highlighting that time was needed to understand the content of PRV images. Student 3-B-SCV concluded: “I need time to understand the picture content [PRV].” This perception resonated with the responses of other PRV students. For example, Student 5-G-PRV stated: “Some pictures [PRV] were not clear for me, so I needed time to think about the content of the picture [PRV].” Similarly, Student 6-G-PRV explained that “thinking about the content of the pictures [PRV] can take a long time”.

6.4 Discussion

6.4.1 Key Advantages of Using SCV and PRV

Key advantages of using SCV and PRV were highlighted by two sub-themes. The first of these consisted of the perceived advantages of using SCV, which included two codes: help in visualising mathematical word problems and help in providing information about mathematical word problems. The second sub-theme was represented as the perceived advantages of using PRV, which included codes that were similar to those named under the first sub-theme.

Much of the literature highlights the benefits of visualisation for improving students' mathematical word problem-solving ability. The current study focused on testing Papert's (1993) constructionist theory, which argues that students learn better by externalising their thinking through the creation of a public artefact. In the context of this current study, the public artefact consisted of students creating their own visualisation to express mathematical word problems (SCV).

The findings from the interview data support what the relevant literature says about visualisation helping to accelerate understanding by adding meaning to abstract problems, such as verbal or word problems (Hanna & Villiers, 2012; Bruter, 2013; Dur, 2014). Dur (2014) also states that visualisation can enhance the clarity of patterns and themes in a systematic manner, which increases the perceptibility of the skills being taught. Therefore, it could be argued that visualisation can develop students' ability to solve mathematical word problems (Bruter, 2013; Dur, 2014), which emphasises the importance of mathematical representation in mathematical learning and understanding (Bruner & Kenney, 1965; Piaget, 1985; Duval, 1999; Tall, 2004).

Furthermore, the literature reveals that external representation, or Bruner's (1966) iconic mode of representation (in this study, SCV and PRV) can enhance internal representation (Múñez, Orrantia & Rosales, 2013). Arguably, this indicates that internal and external representation are linked with each other (Goldin & Kaput, 1996, Orrantia & Múñez, 2012), and both can lead to enhanced mental images (Jitendra et al., 2016). In addition, using visualisation can improve the ability to conceptualise understanding (Bruner, 1966; Kilpatrick et al., 2001) and intelligent learning (Skemp, 1989).

The students' perceptions suggest that SCV and PRV are beneficial for solving mathematical word problems. It could be argued that both types of visualisation (SCV and PRV) develop similar skills in visualising word problems, which help by providing information about mathematical word problems. This could explain the statistically insignificant results in the intervention phase (Chapter 4), leading to the conclusion that Papert's (1993) constructionist theory was not confirmed by the current study. Papert argued that externalisation is more effective, but the lack of it (PRV) made no difference to the students' test scores in this current study (see Chapter 4).

The advantages of using SCV and PRV to solve mathematical word problems were highlighted by students in both groups (SCV and PRV). According to their perceptions, both types of visual representation of the mathematical situation were beneficial for solving mathematical word problems. This finding supports the relevant literature that visualisation can help develop understanding by adding meaning to abstract problems (word problems; Hanna & Villiers, 2012; Bruter, 2013; Dur, 2014). Consequently, most of the students' perceptions emphasised that SCV or PRV helped build their understanding of how to solve mathematical word problems by visualising and providing information about them.

Therefore, it can be argued that the use of visualisation developed the students' ability to solve mathematical word problems (Bruter, 2013; Dur, 2014). This finding also emphasised the importance of mathematical representation in developing mathematical learning and understanding (Bruner & Kenney, 1965; Duval, 1999; Piaget, 1985; Tall, 2004), as the majority of the students' perceptions showed that using SCV (and PRV) helps solve mathematical word problems. Both types of visualisation helped students visualise the mathematical word problems and provided information about these problems. This point supports Dur's (2014) conclusion that visualisation increases the perceptibility of the skills being taught.

Since using SCV and PRV helped with visualising mathematical word problems, the students also developed their mental image, or what Jitendra et al. (2016) refers to as 'internal representation', by improving their representation ability using visualisation (SCV and PRV). This result supports Múñez, Orrantia and Rosales's (2013) finding, which determined that the use of external representation (in this study, SCV and PRV) can enhance internal representation, while internal and external representations are linked to each other (Goldin & Kaput, 1996, Orrantia & Munez, 2012).

Furthermore, students may have developed their conceptual understanding (Kilpatrick et al., 2001) when solving mathematical word problems by improving their mental images. The students' perceptions indicated that using SCV and PRV enhanced their thinking as students with ADHD, and developed their cognitive ability to solve mathematical word problems, as argued by Giaquinto (2011) and Sorva et al. (2013). The students were also able to use Bruner's (1966) iconic mode of representation, which was evident in the SCV and PRV forms used in this current study to reach a solution (symbolic mode of representation).

This discussion can explain the results in the intervention phase, as there were no statistical differences between the SCV and PRV groups in terms of solving mathematical word problems. Some PRV students used SCV in their post-test and delayed test (see Chapter 4). The students in both groups developed the same ability to solve mathematical word problems. This finding also explains how visualisation (via SCV and PRV) developed ADHD students' ability to solve mathematical word problems by visualising them and providing information about these problems.

6.4.2 Key Disadvantages of Using SCV and PRV

The interview data showed that the main disadvantages of using SCV were linked to the codes, a dislike of drawing, cognitive load when drawing, physical discomfort when drawing, and the perception that it was time-consuming to draw images. The interview data also underscored the disadvantages of using PRV, linked with the codes: given images not being useful, cognitive load when processing the given PRV images, and the time-consuming nature of processing the given images. These disadvantages affected the students' preference for using PRV over SCV, or vice versa and their future adoption decisions.

6.4.2.1 Cognitive Load

As these students were using external representations (SCV and PRV), it can be argued that cognitive load should not have existed. The rationale underpinning cognitive load while using SCV and PRV could be linked to the connection between external and internal representation, because external representation can enhance internal representation (Múñez et al., 2013). As the students developed their mental images through external representations (SCV and PRV), a higher level of thinking was necessary, such as explaining and analysing problems to reach a solution (Goldin & Shteingold, 2001). Thus, cognitive load and time-consuming activities were expected results.

This type of cognitive load, called germane load, refers to the effort involved in developing a plan to achieve meaningful learning by becoming more adept at developing alternative ways of solving problems (Roodenrys, Agostinho, Roodenrys & Chandler, 2012; Howarth, 2015). Germane load is very similar to intelligent learning (Skemp, 1989) and conceptual understanding (Kilpatrick et al., 2001), where students are expected to manipulate the problem information and provide an explanation for the solution by learning to represent a problem in a different manner.

Another reason for cognitive load when using SCV and PRV could be linked to the limited working memory of students with ADHD, as a result of EF (Hughes & Graham, 2002; Willcutt et al., 2005; Etnier & Chang, 2009). An inability to recall and hold information in the mind (Barkley, 1997; Kofler et al., 2014) could be the primary reason for the students' perceived cognitive load.

6.4.2.2 Time-consuming Nature

The SCV and PRV students also highlighted their perception of the time-consuming nature of using SCV or PRV. The analysis of the interview data revealed that SCV can be time-consuming, because drawing an image can take a great deal of time. In addition, according to some students, even PRV can be time-consuming, as it takes time to mentally process images. It could be argued that the time that the students thought they needed to draw images or process images could be linked with their lack of working memory, as students with ADHD. The literature emphasises that students with ADHD are unable to maintain the order of a sequence of events over a long period of time, which can affect their ability to recall and retain information (Barkley, 1997; Kofler et al., 2014). Thus, students with ADHD might need adequate time to recall information that already exists in their mind, regarding a mathematical word problem, and to translate it using SCV or PRV.

Furthermore, the ADHD sufferer anticipates planning and faces a deficit in time organisation (Barkley, 1997; Kofler et al., 2014). Therefore, time was a crucial element for students in the current study to plan what to draw. This point was clearly highlighted in some of their perceptions, which also indicated a lack of knowledge about using SCV. Furthermore, the EF component negatively affects the working memory and impairs the ability to concentrate (Willcutt et al., 2005), arguably increasing the time required to focus.

6.4.2.3 Physical Discomfort

In addition, this study highlighted different types of physical discomfort when solving mathematical word problems using SCV, such as headaches, feeling tired, and hurting hands. Students with ADHD have limitations to their working memory, which affects their ability to recall and retain information in the mind (Barkley, 1997; Kofler et al., 2014). This limitation could arguably cause some students to experience headaches when trying to use either type of visualisation to solve mathematical word problems. Furthermore, Smith (2016) claims that using the visual memory can cause headaches, thereby affecting the ability to learn. However, only six word problems were included in each daily session, and only the SCV students used SCV in their daily sessions, while the PRV students used SCV for just one session (the reversed session). Nevertheless, both SCV and PRV students reported that SCV caused their hands to hurt, because of the need to do a substantial amount of drawing.

6.4.2.4 Dislike of Drawing and Given Images Are Not Useful

In terms of the benefits of using SCV (Rellensmann et al., 2017), namely enhancing awareness of the objects involved in the task and their relationships (Van Meter & Garner, 2005), and promoting strong focus on the information in the task (Van Meter & Garner, 2005; Rellensmann et al., 2017), the interview data showed that some students did gain these benefits. They found that SCV helped them solve the word problems and develop their mathematical word problem-solving ability. However, this result contravenes Rellensmann et al.'s (2017) argument that drawing can provide a description of the problem to enhance the likelihood of finding a solution. Some scholars, such as Leutner et al. (2009), have predicted that drawing might not be beneficial for students, if it causes cognitive load; thus, constructing a drawing should not be too demanding. This might explain why some students in both the SCV and PRV groups disliked the use of drawing for as a problem-solving tool.

However, the students also suggested that PRV might not be useful, which contradicts the literature. Scholars have argued that visual images can positively influence mathematics learning and change students' attitudes towards mathematical concepts (Arcavi, 2003; Bjuland, 2007; Gal & Linchevski; 2010). The use of PRV is expected to enable the student to visualise the information in mathematical word problems. This might be the case for some students, but not for all, which supports Tversky's (2010) standpoint. Tversky argued that images (diagrams) can cause confusion for learners, impairing their ability to conceptualise the meaning of an image. The use of sketches can in fact be vaguer than diagrams, which could explain why some of the students failed to find PRV useful. The interview data showed that for some students, PRV was not clear, as they could not understand the images clearly. This supports Gates' (2018) argument that it is not easy to figure out if an image represents what it is supposed to, which would explain the learners' confusion over using PRV. Therefore, these students did not promote the use of PRV, because they did not see how it would help them solve mathematical word problems more easily. Widodo and Ikhwanudin (2018) also mention that the use of visual media is not beneficial for learning mathematics, as the students did not show an increased ability to solve mathematical problems.

6.5 Summary

In summary, it could be argued that the cognitive load caused by using SCV or PRV to solve mathematical word problems is the main reason for the disadvantages identified in the interview data. Since the students' perceptions highlighted cognitive load and physical discomfort, it was acceptable that some underscored their dislike of drawing (SCV) and claimed that the given images (PRV) were not useful. Furthermore, as the students in both groups highlighted a similar disadvantage of using SCV and PRV, this could explain the statistically insignificant results in their mathematical word problem-solving ability (as noted in Chapter 4). Conversely, this finding suggests that Papert's (1993) theory was not confirmed by the current study, as the SCV students did not significantly outperform their PRV counterparts.

CHAPTER 7: ANALYSIS AND FINDINGS FOR RESEARCH QUESTION FOUR

7.1 Introduction

This chapter is divided into two parts to answer the fourth research question (*What are the teachers' perceptions of the influences of using SCV and PRV while solving mathematical word problems, and on the behaviour of students with ADHD?*). The first part presents the analysis of the quantitative survey data and findings relating to the fourth research question, while the second part presents the analysis of qualitative interview data and findings. The findings are critically discussed, and connections made to relevant literature at the end of this chapter.

7.2 Reliability: Internal Consistency of the Surveys

Before analysing the survey data, it was important to check the reliability by measuring the Cronbach's alpha value (Cronbach, 1951) in order to ascertain if removing any items would increase the reliability of the survey. By using the Cronbach's alpha value, the internal consistency will be increased because Cronbach's alpha measures the internal consistency to show how reliable the surveys' scales are. Internal consistency is referred to as the degree to which the instrument measures what it intends to measure (Marrie et al., 2018); this means all survey items should be measuring one thing and they should be interrelated with each other.

The analysis yielded a Cronbach's alpha value of 0.923 for both survey scales together. This signifies a good level of internal consistency and shows that the surveys are reliable and consistent. According to Cronbach (1951), if the value is close to 1, the instrument can be considered to have internal consistency. Therefore, the interpretation of a Cronbach's alpha value of 0.923 means that almost 90% of the survey is reliable and no items need to be removed from the surveys; by extension, 10% of the surveys items can be removed to increase the internal consistency of the surveys items.

The Cronbach's alpha value calculated for each scale (ADHD mathematical word problem-solving ability, ADHD students' intention, and ADHD students' hyperactivity/impulsivity) before and after the intervention was applied is shown in Table 7.1. Table 7.1 shows a high value of the Cronbach's alpha for each survey scale. This means no survey items need to be deleted from any scale. In addition, the analysis of the Cronbach's alpha for each item shows high value (see Appendix 7. Reliability Test). Thus, all the survey items were used.

Table 7.1 Cronbach's Alpha value for each scale

	Solving mathematical word problems	ADHD inattention	ADHD hyperactivity/ impulsivity
Pre-intervention	0.911	0.876	0.786
Post-intervention	0.730	0.805	0.779

7.3 Part One: Quantitative Data

7.3.1 Teachers' Perceptions of Students' Mathematical Word Problem-solving Ability before and after the Intervention

Table 7.2 shows the results of descriptive statistics for the comparison between PRV and SCV for teachers' perceptions of the students' mathematical word problem-solving ability. The Table contains four items. The first three items are for the first survey (pre-intervention) and are numbered as Item 1 (pre), Item 2 (pre), and Item 3 (pre). Similar questions were asked in the second survey (Post-intervention), except for the fourth item which was only asked in the post-intervention survey (see Table 7.2); these items are numbered as Item 1 (post), Item 2 (post), and Item 3 (post).

As Table 7.2 shows, in relation to Item 1 (pre), the majority of SCV teachers' perceptions showed uncertainty about whether their ADHD students can identify or not the type of mathematical operation (division vs. multiplication) in word problems (M = 3.60, S.D. = 1.64). However, teachers in the PRV group disagreed with this belief (M = 2.50, S.D. = 1.65). There was no statistically significant difference between the teachers' perception in the two groups.

In the post-intervention survey Item 1 (post), the majority of the SCV teachers' perceptions were similar to the PRV teachers' perceptions; teachers in both groups were not sure if their students could identify the type of mathematical operation (division vs. multiplication) in word problems (see Table 7.2). There was no statistically significant difference in the teachers' perceptions in the two groups.

The teachers' perceptions in the pre-intervention survey (Item 2 (pre)) showed that the majority of SCV teachers did not agree that students could provide a solution for most mathematical word problems; the majority of PRV teachers were also not sure (see Table 7.2). However, teachers in both groups emphasised that they were not sure if their ADHD students could solve most mathematical word problems after the intervention (see Table 7.2). Consequently, the statistically insignificant results compared teachers' perceptions in both groups on the pre-intervention and post-intervention surveys.

Regarding Item 3 (pre) and Item 3 (post), the majority of teachers in both groups were not sure if their students used any drawing strategies to solve mathematical word problems in the pre-intervention and post-intervention (see Table 7.2). Therefore, statistically insignificant results were clarified in Table 7.2 by comparing teachers' perceptions of Item 3 (pre) and Item 3 (post). Finally, Item 4 was only used in the post-intervention survey. Table 7.2 shows that the majority of teachers in both groups did not think that they noticed any improvement in students' mathematics performance in general. Statistically insignificant results were found by comparing SCV and PRV teachers' perceptions of any improvements in the students' mathematics performance.

Table 7.2 Comparison of SCV and PRV teachers' perceptions of students' mathematical word problem-solving abilities before and after the intervention

		N	Mean	Standard Deviation (SD)	Sig. (2-tailed)
Item 1(pre): The students cannot identify the type of mathematical operation if it is a division or a multiplication in word problems for most problems					
Pre-intervention	PRV	10	2.50	1.65	**0.153**
	SCV	10	3.60	1.64	
Item 1(post): The student can identify the type of operation if it is division or multiplication in word problems for most problems					
Post-intervention	PRV	10	3.00	1.155	**0.584**
	SCV	10	2.70	1.252	
Item 2 (pre): The student is able to provide a solution for most mathematical word problems					
Pre-intervention	PRV	10	2.80	1.31	**0.220**
	SCV	10	2.00	1.49	
Item 2 (post): The student is able to provide a solution for most mathematical word problems					
Post-intervention	PRV	10	3.00	1.054	**0.470**
	SCV	10	3.40	1.350	
Item 3 (pre): The student did not use any drawing strategies to find the solution					**0.574**

Pre-intervention	PRV	10	3.20	1.81	
	SCV	10	3.60	1.26	
Item 3 (post): The student uses drawing strategies to find the solution					
Post-intervention	PRV	10	2.90	1.37	**0.866**
	SCV	10	3.00	1.24	
Item 4 (post): I noticed an improvement in students' mathematics performance in general					
Post-intervention	PRV	10	2.10	1.19	**0.866**
	SCV	10	2.20	1.39	

7.3.2 Teachers' Perceptions of ADHD Students' Inattention Behaviour before and after the Intervention

Table 7.3 shows the *t*-test results comparing SCV and PRV teachers' perceptions of ADHD students' inattention behaviour, before applying the intervention. Table 7.3 shows that the majority of SCV teachers' perceptions almost agreed with survey Item 1 (pre-I): *The student is missing details.* Meanwhile, PRV teachers were unsure if their ADHD students were missing details while solving mathematical word problems. Accordingly, the *t*-test showed a statistically insignificant result comparing teachers' perceptions in Table 7.3.

The majority of SCV teachers' perceptions agreed with survey Item 2 (pre-I)—The student's works are inaccurate to some extent (see Table 7.3)—while PRV teachers were unsure. Therefore, the *t*-test result showed a statistically insignificant result ($p > 0.05$) when comparing SCV and PRV teachers' perceptions of Item 2 (pre-I). For survey Item 3 (pre-I) (The student is facing difficulties remaining focused on tasks), Table 7.3 highlighted that the majority of teachers in both groups were unsure if their students with ADHD faced difficulties remaining focused while solving mathematical word problems. Hence, the *t*-test result was insignificant (see Table 7.3).

The *t*-test result for survey Item 4 (pre-I) was insignificant. The majority of SCV teachers were unsure about this survey item (i.e. the student's mind seems to be elsewhere). The teachers in the PRV group almost agreed that their students' minds seemed elsewhere (see Table 7.3). Regarding survey Item 5 (pre-I) (i.e. easily distracted), teachers in both groups were unsure if their students were easily distracted before the intervention ($p > 0.05$; see Table 7.3). A similar result was found for survey Item 6 (pre-I): The student is facing difficulties organising the task, such as deciding what to do, what to draw, and how to organise the drawing and the ideas.

Table 7.3 shows that the majority of SCV teachers agreed with Item 7 (pre-I), but the PRV teachers were not sure, resulting in insignificant results about whether students avoid engaging in tasks. The comparison of teachers' perceptions of survey Item 8 (pre-I) (Forgets daily activities) was similarly statistically insignificant (see Table 7.3), as teachers in both groups were unsure about their ADHD students forgetting daily activities.

Based on the descriptive and *t*-test results of comparing teachers' perceptions about students' ADHD behaviour (inattention) after the intervention (see Table 7.3), the majority of SCV teachers seemed unsure about Item 1 (post-I) (i.e. missing details) while PRV teachers disagreed with this survey item. Similar results emerged for Item 2 (post-I), Item 3 (post-I), and Item 7 (post-I), all of which showed a statistically insignificant result ($p > 0.05$), as shown in Table 7.3.

However, for the remaining survey items (Item 4 (post-I), Item 5 (post-I), Item 6 (post-I), and Item 8 (post-I)), the majority of SCV and PRV teachers were unsure, and the *t*-test showed statistically insignificant results for all these items (see Table 7.3).

Table 7.3 Comparison of PRV and SCV teachers' perceptions of students' ADHD inattention behaviour before and after applying the intervention

		N	Mean	Standard Deviation	t	df	Sig. (2-tailed)
ADHD inattention (pre-intervention)							
Item 1 (pre-I): The student is missing details	PRV	10	2.70	10			
	SCV	10	3.80	10			
					-1.700	18	**0.106**
Item 2 (pre-I): The student works are inaccurate to some extent	PRV	10	2.70	10			
	SCV	10	3.80	10			
					-1.700	18	**0.106**
Item 3 (pre-I): The student is facing difficulties remaining focused on tasks	PRV	10	2.90	1.663			
	SCV	10	3.10	1.197			
					-0.309	18	**0.761**
Item 4 (pre-I): The student's mind seems elsewhere	PRV	10	3.90	1.370			
	SCV	10	3.10	1.370			
					1.305	18	**0.208**
Item 5(pre-I): Easily distracted	PRV	10	3.40	1.350			
	SCV	10	3.10	1.663			
					0.443	18	**0.663**
Item 6 (pre-I): The student is facing difficulties in organising tasks, such deciding what to do, what to draw, and how to organise the drawing and ideas	PRV	10	2.80	1.398			
	SCV	10	3.40	1.350			
					-0.976	18	**0.342**
Item 7 (pre-I): Avoids engagement in tasks	PRV	10	2.60	1.350			
	SCV	10	3.50	1.434			

					-1.445	18	**0.166**
Item 8 (pre-I): Forgets daily activities	PRV	10	3.14	1.464			
	SCV	10	3.30	1.636			
					-0.203	15	**0.842**
ADHD inattention (post-intervention)							
Item 1 (post-I): The student is missing details	PRV	10	2.40	1.075			
	SCV	10	3.40	1.265			
					-1.905	18	**0.073**
Item 2 (post-I): The student works are inaccurate to some extent	PRV	10	2.40	1.075			
	SCV	10	3.40	1.265			
					-1.905	18	**0.073**
Item 3 (post-I): The student is facing difficulties remaining focused on tasks	PRV	10	2.30	1.059			
	SCV	10	2.80	1.398			
					-0.901	18	**0.379**
Item 4 (post-I): The student's mind seems elsewhere	PRV	10	3.30	1.494			
	SCV	10	2.70	1.252			
					0.973	18	**0.343**
Item 5 (post-I): Easily distracted	PRV	10	2.50	1.080			
	SCV	10	3.40	1.506			
					-1.536	18	**0.142**
Item 6 (post-I): The student is facing difficulties in organising tasks, such as deciding what to do, what to draw, and how to organise the drawing and the ideas	PRV	10	2.80	1.033			
	SCV	10	3.10	1.370			
					-0.553	18	**0.587**

Item 7 (post-I): Avoids engagement in tasks	PRV	10	2.40	0.843			
	SCV	10	3.30	1.494			
					-1.659	18	**0.115**
Item 8 (post-I): Forgets daily activities	PRV	10	3.00	0.816			
	SCV	10	2.56	1.333			
					0.773	14	**0.452**

7.3.3 Teachers' Perceptions of the Students' ADHD Hyperactivity/Impulsivity Behaviour before and after the Intervention

Table 7.4 shows the descriptive and *t*-test results comparing SCV and PRV teachers' perceptions of the behaviour of students with ADHD (hyperactivity and impulsivity), before applying the intervention. The majority of teachers in both groups seemed unsure about whether their students with ADHD were tapping their hands or feet (Item 1 (pre-H)) while solving mathematical word problems or if they often left their seat or did not remain seated (Item 3 (pre-H)), as shown in Table 7.4.

Teachers in both groups agreed that their ADHD students were not moving in their seats (Item 2 (pre-H)). SCV teachers agreed with survey item 5 (pre-H) ("Uncomfortable being still for an extended time"), but the majority of PRV teachers disagreed, saying that their ADHD students were comfortable being still for an extended period time before applying the intervention. Furthermore, the majority of SCV teachers agreed with Item 4 (pre-H), but the PRV teachers were not sure about this statement. A similar perception emerged for survey Item 6 (pre-H) ("Talks excessively"). All survey items related to ADHD students' hyperactivity/impulsivity behaviour before applying the intervention showed statistically insignificant results ($p > 0.05$), as shown in Table 7.4.

Table 7.4 also shows the descriptive and *t*-test results comparing SCV and PRV teachers' perceptions of ADHD students' behaviour (hyperactivity and impulsivity) after the intervention. According to the teachers' perception, the majority of SCV teachers were unsure about survey Item 1 (post-H) (Taps hands or feet) after applying the intervention while PRV teachers suggested such behaviour seemed to decrease. Similar perceptions were found for survey Item 6 (post-H) (Talks excessively).

Table 7.4 also shows that the majority of teachers in both groups were not sure about the impact of the intervention on ADHD students' behaviour of moving in their seats (Item 2 (post-H)) and whether their students often left their seats or remained seated (Item 3 (post-H)). However, for survey Item 4 (post-H) (Runs or climbs in inappropriate situations), SCV teachers indicated that their students with ADHD still ran or climbed in inappropriate situations after the intervention while the PRV teachers were unsure of this behaviour.

Regarding survey Item 5 (post-H) (Uncomfortable being still for an extended time), Table 7.3 shows that the SCV teachers were not sure if the intervention made ADHD students more or less comfortable for extended time. However, the PRV teachers believed their students were more comfortable after the intervention.

Finally, Table 7.4 shows statistically insignificant results for all survey items comparing SCV and PRV teachers' perceptions of students' ADHD hyperactivity/impulsivity behaviour after the intervention ($p > 0.05$), except for survey Item 6 (post-H) (Talks excessively), which showed significant results ($t(18) = -2.726$, $p = 0.014$).

Table 7.4 Comparison of PRV and SCV teachers' perceptions of ADHD students' hyperactive/impulsivity behaviour before and after intervention

		N	Mean	Standard Deviation	t	df	Sig. (2-tailed)
ADHD hyperactivity/impulsivity (before the intervention)							
Item 1 (pre-H): Taps hands or feet	PRV	10	2.60	1.713			
	SCV	10	3.10	1.524			
					-0.690	18	**0.499**
Item 2 (pre-H): The student moves in the seat	PRV	10	3.70	1.703			
	SCV	10	3.90	1.370			
					-0.289	18	**0.776**
Item 3 (pre-H): Often leaves the seat, does not remain seated	PRV	10	3.20	1.751			
	SCV	10	3.40	1.578			
					-0.268	18	**0.791**
Item 4 (pre-H): Runs or climbs in inappropriate situations	PRV	10	2.80	1.751			
	SCV	10	4.00	1.633			
					-1.585	18	**0.130**
Item 5 (pre-H): Uncomfortable being still for an extended time	PRV	10	2.30	1.494			
	SCV	10	3.90	1.370			
					-2.495	18	**0.023**
Item 6 (pre-H): Talks excessively							
	PRV	10	2.80	1.619			
	SCV	10	3.60	1.350			
					-1.200	18	**0.246**

ADHD hyperactivity/impulsivity (after the intervention)							
Item 1 (post-H): Taps hands or feet	PRV	10	1.80	1.229			
	SCV	10	2.70	1.160			
					-1.684	18	**0.109**
Item 2 (post-H): The student moves in the seat	PRV	10	2.80	1.619			
	SCV	10	2.90	1.287			
					-0.153	18	**0.880**
Item 3 (post-H): Often leaves the seat, does not remain seated	PRV	10	3.20	1.751			
	SCV	10	3.40	1.578			
					-0.429	18	**0.673**
Item 4 (post-H): Runs or climbs in inappropriate situations	PRV	10	2.60	1.578			
	SCV	10	3.50	1.650			
					-1.247	18	**0.228**
Item 5 (post-H): Uncomfortable being still for an extended time	PRV	10	2.30	1.418			
	SCV	10	2.90	1.524			
					-0.911	18	**0.374**
Item 6 (post-H): Talks excessively	PRV	10	2.10	1.449			
	SCV	10	3.70	1.160			
					-2.726	18	**0.014**

7.4 Part Two: Qualitative Data

7.4.1 Introduction

This part of this chapter relies on the findings from semi-structured interviews as a method for data generation. This section starts by briefly discussing the interviewing procedures and techniques; it then provides a brief outline of the interview set up. It also explains types of interview questions and questioning strategies. Finally, the data are analysed, using the constant comparison analysis, to address the fourth research question (i.e. *What are the teachers' perceptions of the influence of using SCV and PRV while solving mathematical word problems, and on the behaviour of students with ADHD?).*

All participating teachers were female and in their 30s. Pseudonyms were used to ensure confidentiality, as mentioned in Chapter 3. For example, 6-B-SCV means that this is the sixth teacher in the boys' schools who was interviewed in the SCV.

7.4.2 Findings and Discussion

The data analysis started by generating the initial codes developed from multiple readings of the transcripts to find common phrases or sentences and patterns or repeated ideas. Initially, 17 codes were identified and grouped into 5 themes. After using the constant comparison analysis by rereading the interview transcripts and looking for any missing views or perceptions, the codes were reduced to 7 categorised into three different themes, as shown in Figure 7.1. Therefore, the qualitative analysis and the interpretation of the data are subjective.

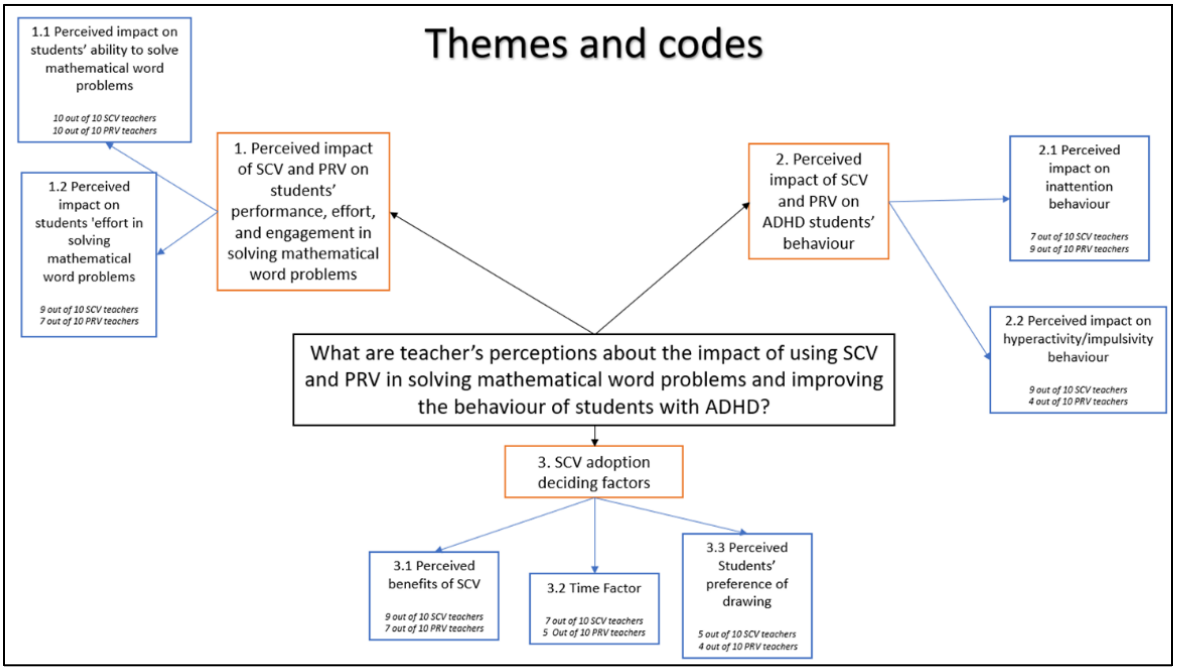


Figure 7.1. The themes and codes

7.4.2.1 Theme 1: Perceived Impact of SCV and PRV on Students' Performance, Effort, and Engagement in Solving Mathematical Word Problems

This theme concerns teachers' perceptions of the extent to which SCV and PRV helped improve ADHD students' ability to solve mathematical word problems. In addition, this theme highlights the teachers' perceptions of the level of effort and participation to solve mathematical word problems by using SCV and PRV. The theme is made up of three codes. The code perceived impact on students' ability to solve mathematical word problems concerns teachers' perceptions of whether the intervention helped students with ADHD to solve mathematical word problems. The code, perceived impact on students' effort in solving mathematical word problems concerns teachers' perceptions of whether the intervention helped students with ADHD display more effort in solving these problems. Finally, the code, perceived impact on student engagement while solving mathematical word problems concerns teachers' perceptions of whether the intervention helps students with ADHD become more engaged with the mathematics class to solve mathematical word problems.

7.4.2.1.1 Perceived Impact on the Students' Ability to Solve Mathematical Word Problems

The interview data showed that all SCV teachers responded to this code, highlighting that the majority of SCV students showed improvement in solving mathematical word problems. One exception was Student 6-B-SCV (see the teachers' responses in Appendix 5). The teachers highlighted that students' mathematical word problem-solving ability improved because they were relying on using drawing (examples of teachers' perceptions are included in Appendix 5). Interestingly, even some PRV teachers believed that their students showed improvement in solving mathematical word problems by using drawing. For example, Teacher 1-B-PRV said, "the student started to do some drawing to solve mathematical word problems", and Teacher 2-B-PRV explained that "the student's ability to solve the problems is improved by using drawing such as lines, circles, and elements". Teacher 6-B-PRV stated that, "by using drawing, his understanding of the word problems is improved".

The teachers' perceptions indicate that using SCV affected students' ability to solve mathematical word problems. Even those who did not use SCV in the PRV group started to rely on drawing as a way to help solve mathematical word problems. This result supports the result from the intervention design, where both groups (SCV and PRV) showed a similarity in their mathematical word problem-solving ability. Furthermore, the interview data offered more clarification about the ADHD students' mathematical word problem-solving ability than the teachers' perceptions by using the surveys (Part one: Quantitative data), as in the surveys some teachers were not sure if the students' ability had improved.

7.4.2.1.2 Perceived Impact on the Students' Efforts in Solving Mathematical Word Problems

Nine out of 10 SCV teachers responded to questions about this code. Most teachers highlighted that their students with ADHD showed more effort in solving mathematical word problems than before by using drawing (see Appendix 5 for examples of teachers' responses). The analysis of the interview data revealed teachers' perceptions of students' effort by using the word "trying" or the student "started" to do something he/she had not done before. For example, Teacher 1-B-SCV said, "he did not provide answers, but he is trying to draw. Sometimes I noticed that he started to highlight all the given information". Teacher 5-B-SCV similarly indicated: "I have noticed that he is relying on drawing to solve the problems. Before he did not even try." Teacher 5-B-SCV's view was parallel to Teacher 10-G-SCV's perception, which highlighted that "she is starting to use drawing especially for multiplication and division". Only Teacher 6-B-SCV reported a negative perception, because her student remained the same even after the intervention: "No, the tool was not effective because the student did not try to use any strategy for solving."

This code was also highlighted by seven out of 10 PRV teachers. All seven responses indicated that students made an effort to solve mathematical word problems (for further responses from the PRV teachers, see Appendix 5). The transcript analysis revealed more expressions reflecting the students' effort among PRV teachers than SCV teachers. PRV teachers' perceptions first underlined students' efforts in solving mathematical word problems. They used words like "effort", "motivation", and "trying". Teacher 2-B-PRV said, "I can see more effort and motivation. He is trying to be a part of the class by trying to solve the problems that I gave in the class". Meanwhile, Teacher 5-B-PRV claimed: "he is trying to provide an answer." Teacher 6-B-PRV also reported an identical view of her student's effort: "I can see that he is thinking and trying to understand how to solve things. He stopped saying I do not want to solve. Now he is trying."

Some PRV teachers were specific in their answers; they reported their students' effort by attempts to use SCV to solve mathematical word problems. Teacher 1-B-PRV said, "For example, if I give them a problem to solve in multiplication or division, he puts circles and divides them to the points or lines; this surprised me". Teacher 7-G-PRV explained that, "yes, she is trying to solve, especially when I gave her a division problem, she solves it by drawing". Similarly, Teacher 8-A-PRV highlighted: "I have noticed her drawing circles with elements to solve some difficult problems. Her performance has become better than before, especially in the recent period where her participation become more, and she is trying to solve the problems."

Thus, based on teachers' perceptions of the perceived impact on students' effort in solving mathematical word problems code, it can be concluded that most students in both groups (SCV and PRV) showed similar effort in solving mathematical word problems. This result provides a reason for the statistically insignificant result in the intervention design when comparing SCV and PRV in their impact on ADHD students' ability to solve mathematical word problems (see Chapter 4). The interview data from the teachers suggest that students in both groups developed a similar ability to solve mathematical word problems.

7.4.2.2 Theme 2: Perceived Impact of SCV and PRV on the Behaviour of Students with ADHD

This theme concerns teachers' perceptions of the improvement of ADHD behaviour (inattention and hyperactivity/impulsivity) after the intervention. This theme is made up of two codes: perceived impact on inattention behaviour, and perceived impact on hyperactivity/impulsivity behaviour.

7.4.2.2.1 Perceived Impact on Inattention Behaviour

This code concerns teachers' perceptions of whether the intervention affected students' ADHD inattention while solving mathematical word problems after the intervention. The perceived impact on inattention behaviour code was highlighted by seven out of 10 SCV teachers and nine out of 10 PRV teachers. Most teachers' perceptions were positive (see Appendix 5) and included words such as "more focused", "remembering things", "attention become better", "concentration has become better", "forgetting has become less", "less distracted", and "paying attention". However, two of seven SCV teachers did not report changes after using SCV on ADHD students' inattention behaviour. For example, Teacher 6-B-SCV stated: "No, there is no change, he is still distracted." Teacher 8-G-SCV likewise reported: "I did not notice any change in her behaviour or her performance."

Some PRV teachers also had perceptions of no impact of using PRV with ADHD students, Four out of nine PRV teachers reported that they did not notice any development in their students' behaviour after PRV. For example, Teacher 1-B-PRV said, "No, I did not feel that the student's behaviour has been changed. I mean no change or trying to control the behaviour". Teacher 7-G-PRV did not notice any changes in the student's behaviour either, because she did not know that she had to observe it: "I do not think so, or maybe I did not pay attention to that. Thus, I did not notice it." Analysing the interview transcripts showed that two PRV teachers thought that this behaviour was beyond students' ability to be controlled, so it could not be changed. According to Teacher 6-B-PRV: "I do not think that he reaches any level of controlling his behaviour yet." Teacher 8-G-PRV supported this: "No, I believe she cannot control her behaviour, because it is something beyond her control."

7.4.2.2.2 Perceived Impact on Hyperactivity/Impulsivity Behaviour

This code concerns teachers' perceptions of whether the intervention affected the ADHD students' hyperactivity/impulsivity behaviour while solving mathematical word problems after the intervention. Regarding the perceived impact on hyperactivity/impulsivity behaviour code, nine out of 10 SCV teachers and four out of 10 PRV teachers responded, with the majority reporting a positive impact. The interview transcripts indicated that most responses included phrases like "not move", "more organised", "aggressive behaviour become less", "not talking without permission", "sitting in the chair not on it", and "shaking his leg" (see Appendix 5).

However, some teachers had negative perceptions of the impact of SCV on ADHD students' hyperactivity/impulsivity behaviour, and some teachers did not notice any changes in their students' behaviour. For example, Teacher 2-B-SCV reported that "Let us say a little, not too much. Sometimes he moves, he must move". Similarly, Teacher 4-B-SCV stated, "No, it did not become less, he still shakes his leg". Teacher 6-B-SCV did not notice any change in her student's behaviour: "No, there is no change, he is still distracted and sometimes he is shaking his leg. He is the same student as before, and I did not notice him trying to do anything to control himself". Meanwhile, Teacher 8-G-SCV said, "I have not noticed anything in her behaviour or her performance".

In addition, two out of four PRV teachers reported perceptions about no impact after using PRV with ADHD students. For example, Teacher 9-G-PRV said, "Not at all, nothing changed, the movement is the same and she is still sitting on the chair". Teacher 10-G-SCV said, "No, the movement in class stays the same, but her level in math improved, even her grades increased at the end of the semester".

Thus, regarding the perceived impact on inattention behaviour and perceived impact on hyperactivity/impulsivity behaviour codes, most teachers had positive perceptions of the impact of using SCV and PRV on the behaviour of students with ADHD. The majority of the teachers reported that their students' inattention and hyperactivity/impulsivity behaviour had improved, although a few teachers did not notice any improvement. These findings support the results from the observation phase, where students in both groups (SCV and PRV) showed a similar improvement in their behaviour (see Chapter 5).

7.4.2.3 Theme 3: SCV Adoption Deciding Factors

This theme concerns teachers' perceptions of whether or not the students had decided to adopt the intervention. This theme is made up of three codes: perceived benefits of SCV, time factor, and students' perceived preference of drawing.

<u>7.4.2.3.1 Perceived Benefits of SCV</u>

This code concerns teachers' perceptions of the benefit of the intervention for students with ADHD. Nine out of 10 SCV teachers and 7 out of 10 PRV teachers highlighted this code. The majority of teachers supported the intervention as they saw a positive impact on their students with ADHD. They said that using SCV and PRV was beneficial and they would use these interventions in their classes. For example, among the SCV teachers, Teacher 2-B-SCV stated: "Because he should learn to use his imagination even if he drew incomprehensible things… Of course, he will benefit a lot." Similarly, Teacher 4-B-SCV said, "It is a good strategy, but the students need practice to master it or understand it", while Teacher 9-G-SCV explained: "I do support this way because it can facilitate the problems."

The PRV teachers offered similar responses (see Appendix 5). For example, Teacher 5-B-PRV said, “I might use drawing [SCV] because it can provoke their thinking”. Teacher 7-G-PRV indicated that using SCV is useful for showing the students’ understanding of the mathematical situation, but she also said she would use PRV if students cannot use SCV: “I will choose drawing [SCV] because it shows the student’s understanding of mathematical word problems. If the student struggles to draw [SCV], then I will give picture and make the student think… Because information can be communicated better by drawing.”

However, two out of nine SCV teachers and three out of seven PRV teachers said SCV was not beneficial for students with ADHD and they would not apply it in their classes. Teacher 1-B-SCV said, “First thing I feel pictures [PRV] are more fun for the child than drawing [SCV]. Second, he [the student] will use his imagination and let him make a little effort to fill his brain with a clear translation of the problem… this way is better and nicer”. Meanwhile, Teacher 6-B-SCV concluded that SCV “was not effective because he [the student] did not use any strategies for solving”.

The PRV teachers classified their decision to not adopt SCV by comparing the benefit of PRV over SCV. Teacher 1-B-PRV reported: “by using pictures [PRV] the problem becomes entrenched in their minds better than drawing [SCV], because they can see a clear visual translation of the problems.” Similarly, Teacher 5-B-PRV said, “as I mentioned before pictures [PRV] are much better than drawing [SCV] where they may draw something not related to the problem and get the wrong answer”. Finally, Teacher 6-B-PRV based her decision on which approach (SCV or PRV) was easier for the student to use: “If I have to choose, I will choose pictures [PRV] because it is easier.”

Interestingly, even teachers who supported the benefits of the intervention found some limitations in applying it. For example, some teachers supported the benefit of using SCV and PRV to solve mathematical word problems, but the students need to be trained to use it. Teacher 4-B-SCV declared, “the students need to practice.” Teacher 8-G-SCV said, “students should have training in how to use it correctly”. Teacher 10-G-PRV reported that receiving training for using SCV is important and that the training should be intensive: “it needs a lot of training about how to draw [SCV] and what to draw.” In addition, in the case of a high level of hyperactivity, this intervention will not work, as Teacher 9-G-PRV explained: “because she [the student] is very hyper thus she cannot sit and draw.”

7.4.2.3.2 Time Factor

This code concerns teachers’ perceptions of whether or not the intervention was suitable or could fit within class time. Seven out of 10 SCV teachers and five out of 10 PRV teachers responded to this code. The majority of teachers thought that using SCV or PRV was time-consuming; therefore, in order to apply SCV or PRV in class, they needed to consider how much time the students would need.

Some SCV teachers preferred to use PRV rather than SCV because it fits within the class time. For example, Teacher 4-B-SCV said, “I will use pictures [PRV] because it fits with class time”. Teacher 9-G-SCV stressed: “it will not take [as much] time as drawing [SCV].” PRV teachers also seemed to prefer PRV over SCV because of the time element (see Appendix 5). Teacher 9-G-PRV said, “I believe this might take all the class time to draw [SCV] one or two problems”. Teacher 10-A-PRV held a similar view: “drawing [SCV] can take time to be done.”

7.4.2.3.3 Perceived Students’ Preference for Drawing

This code concerns teachers’ perceptions of whether students with ADHD tried to apply SCV while solving mathematical word problems. Five out of 10 SCV teachers and four out of 10 PRV teachers responded to this code. The teachers’ perceptions indicated that the intervention can be applied only if the students like drawing (SCV) or have the visual ability to draw, which can enhance the adoption of SCV (see Appendix 5). Teacher 4-B-SCV reported that she will not adopt SCV because not all students like to use SCV; instead, using PRV might be a better option in this case: “I will use pictures [PRV] because it fits with class time and because not all students love drawing.” Similarly, Teacher 3-B-PRV said, “Maybe only for the students who love drawing”. Teacher 8-G-PRV found that her student liked to use SCV, so her view emphasised that only in cases where the students liked to use SCV would she adopt the intervention: “in the case of this student, I think it will work because she likes to draw.”

Another reason for not using or adopting SCV was shown by Teacher 9-G-SCV, who said not all students have the ability to draw (SCV) so not all student would prefer to use SCV: “not every student can draw [SCV]…. Picture [PRV], because students can use it better than they create drawing [SCV]. Externalisation by drawing [SCV] is better than just seeing a picture [PRV], but it depends on the student level and ability.” In addition, considering students’ brain functions is important for some teachers to adopt SCV or even the students’ preference to use SCV. Teacher 6-B-SCV reported: “it depends on the student, where some of them are visual students, these we can use visualization with them, but with those who do not have visual ability I am not sure. It depends on the child himself and what he prefers.”

These teachers' perceptions resonate with some observations about the students' drawing (SCV). Some students can provide a fully detailed drawing while others can only draw lines and circles. During the intervention design sessions, it was noticed that some students complained about too many problems to draw or about feeling tired while solving by drawing. They also complained that they did not to know what to draw. From the teachers' perceptions, it can be concluded that SCV might work only with students who love to draw and have a good visual ability. For those who do not like to draw or do not have visual ability, using pictures (PRV) can be more beneficial.

7.5 Discussion

7.5.1 Discussion of the Survey Data

The main object of the current study was to test Papert's (1993) theory of constructionism. Based on the teachers' perceptions, it could be argued that Papert's theory of constructionism helped develop ADHD students' mathematical word problem-solving ability. Some researchers, such as Hanna and Villiers (2012), Bruter (2013), and Dur (2014), argued that using visualisation helps accelerate understanding by adding meaning to abstract problems (word problems). Therefore, a comparison between the SCV and PRV groups was necessary to understand which type of visualisation (SCV or PRV) was more effective.

This study determined that the impact was not limited to using SCV only; using PRV showed a similar impact as well. However, some scholars emphasised the benefits of generating drawing on the ability to solve problems and increase students' focus. For example, Van Meter et al. (2006) stated that generating drawing could help students develop mathematical word problem-solving ability and help them produce an explanatory representation of a concept described in the text. Rellensmann et al. (2017) highlighted that generating drawing can support the process of solving word problems and can encourage a good focus by observing the task information. Both groups of scholars were supported by SCV teachers' perceptions, but the interview data analysis suggested that the students who did not create drawings (PRV students) developed the same ability to solve problems and their focus increased as much as students in the SCV group.

The independent samples *t*-test showed no statistically significant differences in teachers' perceptions of ADHD students' mathematical word problem-solving ability or their ADHD behaviour across both groups (SCV and PRV) before the intervention. Similar results were found after the intervention. These results from teachers' perceptions support the results from the intervention design phase (Chapter 4) and the observation phase (Chapter 5).

Based on teachers' perceptions as reported in the survey, Papert's (1993) theory of constructionism is not supported by the current study's findings. Specifically, the teachers believed that both students who create public artefacts by generating their own visualisation (SCV) and students who received the visualisation (PRV) showed the same ability to solve mathematical word problems after the intervention. Consequently, it could be implied that training students with learning disabilities to use either form of visualisation could help them improve their mathematical word problem-solving ability by identifying the problem's information and the relationship between the problem data, as indicated by some teachers' perceptions. Arcavi (2003) raised a similar discussion about the impact of using visualisation in developing the analytical process and the ability of representation to reach the solution (Bruner, 1966).

7.5.2 Discussion of the Interview Data

The interview data provided in-depth understanding about the impact of the intervention on ADHD students' mathematical word problem-solving ability and their behaviour. The constant comparative analysis of the interview data highlighted a number of findings. First, the teachers believed that the ADHD students' mathematics word problem-solving ability had improved. This finding supports the literature (for example, Bruner, 1966; Arcavi, 2003; Giaquinto, 2011), and a similar point was found by Skemp (1989), Hershkowitz et al. (2001), Kilpatrick et al. (2001), Jonassen (2003), and Tall (2004) also argued that visualisation can help improve mathematical understanding by enhancing cognitive ability through the development of mental images.

Based on the literature, using visual representation can improve the internal conceptual model which can provide clarification about the learning information and allow for the construction of new knowledge by using images (Sorva et al., 2013; Garderen et al., 2014; Rellensmann et al., 2017), which is the case of the current study using SCV and PRV. In addition, the teachers' perceptions of the development on students' mathematical word problem-solving ability support Bruner's (1966) iconic mode of representation. The analysis of the interview data showed that students were able to solve mathematical word problems depending on their use of visual sensory representations (iconic mode of representation) to build a conceptual understanding for solving symbolic forms (see Chapter 2).

Furthermore, regarding the development of students' focus, this result supports the study by Tsai and Yen (2013), who found a positive effect of using visualisation on students' motivation and responding by making them more active learners. However, Tsai and Yen's (2013) study tested the effect of 3D visual materials to learn geometry, which is different than the tested concepts of the current study. Still, they highlighted the idea of the positive effect of using visualisation on students' learning, as the current study did. In addition, teachers' perceptions from the surveys and the interviews emphasised the role of visualisations (Bruner, 1966; Arcavi, 2003), which was affected by whether this visualisation was created or given to students. Using visualisation affected not only ADHD students' mathematics word problem-solving ability, but also their ADHD behaviour, as will be discussed next.

Teachers reported that students in both groups (SCV and PRV) showed improvements in their ADHD behaviour in relation to inattention and hyperactivity/impulsivity. From this point, the hypotheses could be built concerning the EF, as one of its purposes is directing ADHD behaviour (Etnier & Chang 2009). The interview data showed a change in ADHD behaviour, suggested that a change in ADHD (EF) might have occurred. By using visualisation (either SCV or PRV), students with ADHD might reach a point where they can control an automatic action and decrease the impulsivity implemented by EF. According to Hughes and Graham (2002) and Willcutt et al. (2005), EF is linked with ADHD inhibition behaviour and is responsible for controlling and increasing impulsivity.

Furthermore, the interview data showed that the students' planning and organising ability increased, reflecting the development of their ADHD behaviour, as highlighted by teachers' perceptions. Some researchers, such as Barkley (1997) and Kofler et al. (2014), argued that ADHD have problems with their ability to plan and organise their time, but teachers' perceptions showed that these aspects were resolved for some students after using SCV and PRV.

Finally, based on teachers' perceptions, SCV adoption depends on key elements, such as perceived benefits of SCV, time factor, and students' perceived preference of drawing (SCV).

Regarding the perceived benefits of SCV on students with ADHD, according to the teachers' perceptions, the use of visual representations (SCV and PRV) to solve mathematical word problems was useful. However, some negative perceptions were found in relation to the time factor and students' preference of using drawing (SCV); these perceptions could be associated with cognitive load caused by using SCV and PRV to solve mathematical word problems (see Chapter 6). Representation refers to the ability to simplify the abstract idea by using characters, images, or concrete objects (Bruner, 1966; Jitendra et al., 2016); thus, this transition from an abstract idea to a visual image adds a cognitive load on students with ADHD, making the use of SCV unpleasant and time-consuming.

Furthermore, some teachers found that using SCV can be time-consuming because the visualisation process requires a lot of thinking in order to conceptualise understanding through mental imaging (Bruner, 1966). In addition, students with ADHD have limitations to their working memory (Rapport et al., 2013), which can affect their ability to maintain the order of events over a long period of time as well as the ability to recall and hold information mentally (Barkley, 1997; Kofler et al., 2014).

The discussion thus far has suggested that the study findings contradict Papert's (1993) theory based on the construction of knowledge by creating a public artefact. Accordingly, it could be argued that using visualisation, whether SCV or PRV, developed students' ability to solve mathematical word problems based on the teachers' perceptions. Therefore, Bruner's (1966) iconic mode of representation in general enhanced the ability to solve mathematics word problems and improved students' ADHD behaviour. Arguably, the external representation, whether created (drawing) or given (image), develops intelligent learning (Skemp, 1989) and conceptual understanding (Kilpatrick et al., 2001) for students with ADHD.

Although the teachers' perceptions from the survey provide a good understanding of the intervention's impact, important information was also provided through the teachers' interviews. This information related to the need for training to apply the intervention (SCV), the considerations of students' preference to use drawing, and time factors. However, the surveys and the semi-structured interview findings revealed that, when comparing both groups (SCV and PRV), no differences emerged in ADHD students' mathematics ability to solve word problems or their ADHD behaviour.

The data disclose that the majority of teachers could not distinguish between the impact of using SCV and PRV on ADHD students' ability to solve mathematical word problems or on their behaviour. Based on the teachers' perceptions, the impacts of SCV and PRV are similar.

7.6 Summary

From the analysis and the findings from the survey and interview data, it is apparent that the teachers in both groups highlighted the development of students with ADHD in terms of their mathematical word problem-solving ability and ADHD behaviour (see subsections 7.3.1 and 7.3.2). This can give crucial support to the results from the intervention design and the observations phase, where the results of the paired sample *t*-test indicate that the students in both groups showed improvement. The results from the teachers' perceptions also suggest that there were no differences in the students' ability to solve mathematical word problems or ADHD behaviour, between the two groups (SCV and PRV). This finding concurs with the independent samples *t*-test in the intervention design and observation phases.

The results of the survey and interview data support those of the intervention design in Chapter 4 and the observations in Chapter 5. A *t*-test comparing the teachers' perceptions across the two groups (as elicited via the survey) revealed statistically insignificant results in both SCV and PRV teachers' perceptions of their students' mathematical word problem-solving ability and ADHD behaviour. Similar results were found in the interview data, whereby most teachers across both groups highlighted that the students—regardless of whether they were in the SCV or PRV group—demonstrated improved mathematical word problem-solving ability, as well as a greater ability to focus on the tasks.

CHAPTER 8: CONCLUSION

8.1 Introduction

This research aimed to test Papert's theory of constructionism, which asserts that the externalisation (or projecting out) of students' current understanding to the outside world through the creation of a public artefact is a more effective way of learning. In addition, the current study predicted that using a public artefact by self-constructed visualisation (SCV) through drawing is more effective than using passively received visualisation (PRV). As the current study is one of the first few empirical studies to test the validity of Papert's theory of constructionism, particularly as it relates to the role of externalisation, this study adds new contributions to using visualisation in learning mathematical word problems, especially for students with ADHD. The current study predicted that using this intervention can help in exploring the impact of using visualisation on mathematical word problems solving ability and on students' behaviour by becoming more focused during that word problems solving task.

Therefore, the methods of this study have provided the opportunity to understand how using visualisation can help ADHD students learn solving mathematical word problems for multiplication and division. Adopting an exploratory mixed methods design helped shed additional light on the extent to which SCV can better meet the unique mathematics learning needs of students with special needs, such as ADHD, compared to PRV. It also highlighted the importance of using Bruner's iconic mode of representation and how that mode can enhance the externalisation of information and thinking, thereby promoting clearer intelligent thinking rather than only habit learning (Skemp, 1989) and conceptual understanding rather than simply procedure fluency (Kilpatrick et al., 2001). Ultimately, this study attempted to answer four research questions:

1. To what extent do PRV and SCV help students with ADHD solve mathematical word problems?

2. To what extent do PRV and SCV help students with ADHD remain focused while solving mathematical word problems?

3. What are the perceptions of students with ADHD regarding the advantages and disadvantages of using PRV and SCV to solve mathematical word problems?

4. What are teachers' perceptions of the influence of using SCV and PRV while solving mathematical word problems and of the behaviour of students with ADHD?

8.2 Summary of Key Findings

The results showed that students with ADHD can learn mathematical word problems using visualisation. There was no difference between the groups taught to use different methods of visualisation (SCV and PRV). This result, however, was not the expected one, as the researcher—prior to conducting the study—predicted that SCV students would outperform PRV students. The results also showed that participants improved concentration and behaviour over the course of the study. Both students and teachers reported finding methods of visualisation useful for solving mathematical word problems. In addition, teachers reported that pupils concentrated better and demonstrated improved behaviour as a result of the interventions.

The results presented herein relate to helping special education children with ADHD learn better, and they can be generalised to learning disability classrooms in Kuwait. Although the results showed statistically insignificant differences when using SCV compared to PRV to solve mathematical word problems, both groups improved in their mathematical word problems solving abilities, as calcified by the *t*-test results presented in Chapter 4. Thus, using visualisation was beneficial for ADHD students when solving mathematical word problems, supporting not only Papert's view of using a public artefact, but also Bruner's (1966) iconic mode of visualisation, where using visual aids can improve mathematical understanding by enhancing cognitive ability through the development of mental images. Bruner's view about the benefit of visualisation was also supported by Arcavi (2003), Jonassen (2003), Tall (2004), and Giaquinto (2011). Despite the lack of differences in the ADHD students' behaviour in both groups (SCV and PRV), students in both groups showed improvements in their focus by reducing inattention and hyperactivity/impulsivity. These results indicate the importance of using visualisation, whether by SCV or PRV. Possibly, being calm and more focused while using visualisation (SCV or PRV) might influence ADHD students' mathematical word problems solving ability.

To understand the impact of using externalisation by creating public artefact, which supports Papert's theory, the correlation test subsequently showed an inconsistent weak correlation between SCV use and test scores (see Chapter 4). Table 4.12 in Chapter 4 indicates that some SCV students did not use SCV while some PRV students used SCV when undertaking their tests. Some students seemed to know how to use visualisation before the intervention started as they used visual aids in grades one and two to learn simple mathematical concepts; however, using visualisation to solve mathematical word problems was still a new method for them. In addition, the fact that most of the ADHD students used SCV whether they were taught it specifically or not and that they had already been taught some forms of visualisation by their usual teachers questions the validity of the current study's findings. Nevertheless, the validity of the empirical findings is increased by the teachers' and students' perceptions, which suggest that students and teachers found visualisation useful. However, it can be concluded that the correlation test does not support the idea that self-constructed visualisation is especially helpful. What helped ADHD students solve mathematical word problems and remain more focused while solving mathematical tasks was using visualisation through the iconic mode of representation, not specifically using Papert's theory.

Despite some disadvantages when using SCV and PRV perceived by teachers' and students' interviews data linked with time factors, different abilities in using visualisation, and cognitive load, the advantages of using visualisation either it was by SCV or PRV underscored by both teachers' and students' perceptions. Considering the students' and teachers' perceptions about the impact of using SCV and PRV, both found using SCV and PRV useful especially the teachers, who noticed the impact on their students' behaviour and performance when solving mathematical word problems. According to the teachers, students' participation in mathematics class increased, and they were more engaged with mathematical tasks. The students added that the use of SCV or PRV helped them understand the mathematical word problems by clarifying them in a visual manner. These results do not necessarily support Papert's theory of constructionism, but they strongly support the benefits of using Bruner's iconic mode of representation, which can arguably help ADHD students develop rational thinking (Skemp, 1989) and conceptual understanding (Kilpatrick et al., 2001). In conclusion, the perceived interviews data about the advantages and the disadvantages of using SCV and PRV explain the reason for some students' preference and not the preference of using SCV or PRV which can have influences on ADHD students' mathematical word problems solving ability and on their behaviour.

In summary, the findings related to the first research question arguably illustrate that Papert’s (1993) view of using public artefacts (i.e., SCV) to externalise students’ thinking is a better way of learning. Comparing the impact of using a public artefact (i.e., SCV) with not using a public artefact (i.e., PRV) indicates that both seem to have similar effects on ADHD students’ learning to solve mathematical word problems. Therefore, Papert’s theory of constructionism using the externalisation of students’ thinking as a means of facilitating mathematical problems and their solutions did not hold true for the current study as not using externalisation (PRV) showed similar results. This finding does mean that Papert’s theory did not help ADHD students solve mathematical word problems. On the contrary, using a public artefact to externalise students’ thinking was an effective way to solve mathematical word problems as SCV students showed statistically significant differences between the pre-test and post-test scores analysed using a paired sample *t*-test, just as it was for PRV students. Furthermore, both types of visualisation showed a similar impact on ADHD students’ behaviour in both groups. The interview findings also appear to support the results from the intervention phase, observations, and surveys, as the teachers’ perceptions were more or less similar for the SCV and PRV students, their mathematical word problems solving ability, and their behaviour.

In addition, some of the teachers found PRV to be more suitable for these students and the class time, while others found SCV to be more effective for developing students’ mental images and helping them focus better. However, the students in both groups (SCV and PRV) showed improvement in both their mathematical word problems solving ability and their behaviour. Similar perceptions regarding the students' mathematical word problems solving ability were found in a review of the students' perceptions.

8.3 Limitations of the Study

Nevertheless, some methodological limitations should be noted. For example, the formats of the pre-test, post-test and delayed post-test were identical in terms of the content, number of questions and design. The test content and number of questions were identical across the tests in order to easily measure progress (if any) in students' mathematical word problems solving ability. Additionally, the result of the paired sample *t*-test for each group (SCV and PRV) was logical, which indicates that the content and number of the questions were fine. In designing the questions, those in the pre-test, post-test and delayed post-test did not include extra spaces for each question to clarify how the students obtained their answers. Furthermore, the students were not asked about the processes they used to solve the test questions. This limitation added an element of uncertainty in terms of whether the students used SCV or not, whether they developed images in their minds about the word problems, or whether they simply guessed the answer. Thus, the students' thought processes for understanding and solving the problems in these tests were not known.

The time issue and the small sample size played critical roles in the data of the current study. Arguably, researcher conducted over a longer period than the current study might reveal long-lasting effects of the intervention and provide better results in the delayed post-test; in addition, differences between both groups (SCV and PRV) might emerge. Similarly, regarding the sample size, if the sample were bigger than the one included in the current study, different results might occur.

Regarding the use of SCV, an analysis of the relevance of drawings to the mathematical word problems can be helpful in identifying the extent to which students can represent word problems correctly. As the current study did not deal with the clarity of the images drawn by the students or the extent to which their drawing makes sense to us, what mattered was that the students could represent their understanding by using SCV to make sense for them. Thus, some students did not interpret SCV correctly and, consequently, represented the mathematical word problems incorrectly. Similar issues occurred when using PRV. It is possible that teaching the students how to interpret their drawings by using SCV or using given images with PRV may have impacted the outcomes of the intervention.

Other limitations of the current study included not testing the students for their general mathematical ability before conducting the intervention. Identifying the individual differences in mathematical skill and assigning the students into two groups (SCV and PRV) depending on their mathematical level might have had a different impact on the data than in the current study did. In addition, minimizing students' age to a smaller range (e.g., a single grade instead of an age range between 9 and 11), might directly affect the data and, thus, the outcomes differently. Finally, differences in the types of ADHD were not considered (for further discussion about the importance of considering ADHD types, see Section 5.3 Discussion). Considering the types of ADHD and assessing the students in groups depending on their types might have had diverse influences on the research results, especially when answering the second research question, where ADHD behaviour can be more effectively identified. For example, instead of having all students in only two groups

(SCV and PRV), it is possible to assess one group (i.e., SCV) depending on their ADHD type; similar procedures can be followed for the second group (i.e., PRV) as well.

8.4 Practical and Policy Implications

Drawing from the findings for the first and second research questions, the present study suggests that the use of visualisation has a clear impact on ADHD students' mathematical word problems solving ability as well as their behaviour. This finding did not demonstrate any differences in ADHD students' mathematical word problems solving ability or their behaviour between SCV and PRV application. However, both the SCV group (intervention group) and the PRV group (comparison group) showed improvement in solving mathematical word problems and in their behaviour. From these findings, teachers should be aware of the benefits of using visualisation with students with special needs or learning disabilities and give that technique more attention as part of their overall pedagogy, while making it explicit in their mathematics lesson plans. Based on teachers' perceptions, teachers must decide on their teaching strategies, and a combination of different teaching strategies should be encouraged to develop better learning. Thus, educators, professionals, and educational policymakers should consider the implementation of visualisation in mathematics lessons and the ongoing use of teachers' perceptions and reflections when choosing and implementing any new methods or tools, as it is the teachers who are the daily experts in their respective fields.

8.5 Future Research Directions

The current study opened a door for further research in mathematical education and special education needs. In future research, a bigger sample size may imply and deliver new and different results than those from the current study. In addition, a longer period of intervention might have long-lasting effects on all these students, where it can be argued that even differences between both groups might accrue and be understood. In the future, having sessions that teach students how to read images and understand them or how to draw relevant images for the mathematical word problems might generate different results in the study.

Another suggestion is to analyse the data, especially SCV data, for the relevance of drawing on mathematical word problems. A further suggestion could to include examining the study methodology as well, such as using a quasi-experiment instead of an intervention experiment for potentially different but still important results to see how the students perform in a normal setting. There is also a question about whether the control over students' sitting and sessions should be the same.

Moreover, testing the students' mathematical performance before conducting the study is necessary for categorizing the students into groups (i.e., a high performance group, a mid performance group, and a low performance group). This practice, rather than having a mixture of students in each group, might help identify students' development. A similar procedure for grouping could be followed when assessing ADHD students depending on their types (ADHD-I, ADHD-C, and ADHD-H) and performances.

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APPENDICES

Appendix 1: Ethical Approval

1. Ethical Approval for the Pilot Study

University of Reading
Institute of Education
Ethical Approval Form A (version May 2015)

Tick one:

Staff project: ____ (PhD) ___ EdD ___

Name of applicant (s): Fatemah Almuwaiziri

Title of project: Solving mathematical word problems using passively visualisation (PRV) and self-constructed visualisation (SCV): The case of Attention Deficit Hyperactivity Disorder (ADHD) primary school students in Kuwait.

Name of supervisor (for student projects): Natthapoj Vincent Trakulphadetkrai

Please complete the form below including relevant sections overleaf.

	YES	NO
Have you prepared an Information Sheet for participants and/or their parents/carers that:		
a) explains the purpose(s) of the project	X	
b) explains how they have been selected as potential participants	X	
c) gives a full, fair and clear account of what will be asked of them and how the information that they provide will be used	X	
d) makes clear that participation in the project is voluntary	X	
e) explains the arrangements to allow participants to withdraw at any stage if they wish	X	
f) explains the arrangements to ensure the confidentiality of any material collected during the project, including secure arrangements for its storage, retention and disposal	X	
g) explains the arrangements for publishing the research results and, if confidentiality might be affected, for obtaining written consent for this	X	
h) explains the arrangements for providing participants with the research results if they wish to have them	X	
i) gives the name and designation of the member of staff with responsibility for the project together with contact details, including email . If any of the project investigators are students at the IoE, then this information must be included and their name provided	X	
k) explains, where applicable, the arrangements for expenses and other payments to be made to the participants		X
j) includes a standard statement indicating the process of ethical review at the University undergone by the project, as follows: 'This project has been reviewed following the procedures of the University Research Ethics Committee and has been given a favourable ethical opinion for conduct'.	X	
k)includes a standard statement regarding insurance: "The University has the appropriate insurances in place. Full details are available on request".	X	
Please answer the following questions		
1) Will you provide participants involved in your research with all the information necessary to ensure that they are fully informed and not in any way deceived or misled as to the purpose(s) and nature of the research? (Please use the subheadings used in the example information sheets on blackboard to ensure this).	X	
2) Will you seek written or other formal consent from all participants, if they are able to provide it, in addition to (1)?	X	
3) Is there any risk that participants may experience physical or psychological distress in taking part in your research?		X
4) Have you taken the online training modules in data protection and information security (which can be found here: http://www.reading.ac.uk/internal/imps/Staffpages/imps-training.aspx)?	X	
5) Have you read the Health and Safety booklet (available on Blackboard) and completed a Risk Assessment Form to be included with this ethics application?	X	
6) Does your research comply with the University's Code of Good Practice in Research?	X	

	YES	NO	N.A.
7) If your research is taking place in a school, have you prepared an information sheet and consent form to gain the permission in writing of the head teacher or other relevant supervisory professional?	X		

8) Has the data collector obtained satisfactory DBS clearance?	X		
9) If your research involves working with children under the age of 16 (or those whose special educational needs mean they are unable to give informed consent), have you prepared an information sheet and consent form for parents/carers to seek permission in writing, or to give parents/carers the opportunity to decline consent?	X		
10) If your research involves processing sensitive personal data[1], or if it involves audio/video recordings, have you obtained the explicit consent of participants/parents?	X		
11) If you are using a data processor to subcontract any part of your research, have you got a written contract with that contractor which (a) specifies that the contractor is required to act only on your instructions, and (b) provides for appropriate technical and organisational security measures to protect the data?			X
12a) Does your research involve data collection outside the UK?	X		
12b) If the answer to question 12a is "yes", does your research comply with the legal and ethical requirements for doing research in that country?	X		
13a) Does your research involve collecting data in a language other than English?	X		
13b) If the answer to question 13a is "yes", please confirm that information sheets, consent forms, and research instruments, where appropriate, have been directly translated from the English versions submitted with this application.	X		
14a. Does the proposed research involve children under the age of 5?		X	
14b. If the answer to question 14a is "yes": My Head of School (or authorised Head of Department) has given details of the proposed research to the University's insurance officer, and the research will not proceed until I have confirmation that insurance cover is in place.			X
If you have answered YES to Question 3, please complete Section B below			

Please complete **either** Section A **or** Section B and provide the details required in support of your application. Sign the form (Section C) then submit it with all relevant attachments (e.g. information sheets, consent forms, tests, questionnaires, interview schedules) to the Institute's Ethics Committee for consideration. Any missing information will result in the form being returned to you.

A: My research goes beyond the 'accepted custom and practice of teaching' but I consider that this project has **no** significant ethical implications. (Please tick the box.)	X

Please state the total number of participants that will be involved in the project and give a breakdown of how many there are in each category e.g. teachers, parents, pupils etc.

approximately a minimum of 3 males and 3 females ADHD will be invited to participate in this study in Kuwaiti primary schools.

Give a brief description of the aims and the methods (participants, instruments and procedures) of the project in up to 200 words noting:

1. title of project:
   Research Project (Title): Solving mathematical word problems using passively visualisation (PRV) and self-constructed visualisation (SCV): The case of Attention Deficit Hyperactivity Disorder (ADHD) primary school students in Kuwait.

2. purpose of project and its academic rationale:
   The study aims to help students with ADHD accessing mathematical word problems by using: passively received visualisation (PRV) and self-constructed visualisation (SCV). PRV is when children use given images of objects to help visualise word problems, whereas SCV is when children create their own images and drawings to visualise word problems. Children will use two different apps to assist them during the PRV and SCV phases. It hopes to make recommendations regarding how we can best help learners to make progress in mathematical learning, and how we can best prepare ADHD students understanding mathematical word problems and develop their abilities in solving word problems.

3. brief description of methods and measurements:
   To answer the first research question (To what extent do passively received visualisation (PRV) and self-constructed visualisation (SCV) help ADHD students solve mathematics word problems?) a single-case

[1] Sensitive personal data consists of information relating to the racial or ethnic origin of a data subject, their political opinions, religious beliefs, trade union membership, sexual life, physical or mental health or condition, or criminal offences or record.

experimental design will be used by applying multiple base line design. The current study is designed to have a daily one-to-one session last for maximum 30 minutes for 25 sessions in total. In each session the student will solve 10 word problems. After each 5 sessions, the student will be tested. The test will include 10 word problems which will be solve in 15 minutes. Some students will experience longer period in one phase than the other phase, this to evaluate the effect of each app in different length of time. Furthermore, pre-test will be applied before the beginning of the first session to underline the student's mathematical level. In the end of the experiment (after the last session) a post- test will be applied to evaluate student's development by using PRV and SCV. tests questions will be taken from the authoritative tests files questions from the selected schools of the study. The choice of the test questions will be done with help of the teachers of the same age range selected for the current research. These tests questions will be somewhat similar, but the structure will be different.

To answer the second research problem (To what extent do PRV and SCV help ADHD students remain focused while solving mathematics word problems?), structured observation will be used (quantitative observation) by following scheduled categories that shape the observation in counting the events. The observation is established to observe ADHD changing behaviour in (Inattentions) and (Hyperactive and Impulsivity) while using PRV and SCV through 25 sessions for mathematic word problems. Observing inattentions is divided in to 7 categories and hyperactive and impulsivity is divided to 6 categories. The observation sheet is developed from DSM-5 (Diagnostic and statistical manual of mental disorders) for 25 sessions for each child. Where each child will have daily one-to-one session for maximum 30 minutes. The observations will be collected from a video recorded for each student during the experiment. These observations will indicate the occurrence of the ADHD behaviour. If the behaviour accrue I will put (1), if not accrue I will put (0).

Students interviews will be used to answer the third research questions (What are ADHD children's perceptions on using PRV and SCV to solve mathematics word problems?). Using semi-structured interviews will provide more information about how students with ADHD learn through applying PRV and SCV by using reflections of interviewee views (students). Each child will be interviewed separately twist. First, for at least 13 to 15 minutes before the first session started. This to understand their general abilities to solve mathematic word problems, and if they prefer to use technology (e.g. apps) to solve mathematical problems. The second interviews will take place after the post-test. The interviews questions can take time between 17 to 20 minutes, each question in both interviews might take time between 1 to 3 minutes depend on the nature of the question and the speed of responding. The interviews will be held in safe environment (the schools) at school time. These interviews will be video recorded and transcribed. The transcript will be translated from Arabic to English by using translator.

4. participants: recruitment methods, number, age, gender, exclusion/inclusion criteria:
approximately a minimum of 3 males and 3 females will be invited to participate in this study. The participants will be randomly chosen for the intervention and the phase length.

5. consent and participant information arrangements, debriefing (attach forms where necessary):
As this study will be applied in schools, three types of consent form are needed. First, I need a consent form for the head teacher of each school with information sheet to clarify the natural of study will be held in their schools. Second, I need to develop a consent and information sheet for the parents. This to give a clear idea for the parents about what their children will be involve in, why their children have been chosen, and what are their right. Finally, the child has the right to understand what they are involve in, and their rights as apart of the project. Thus, I developed and information sheet and consents form for the students. As Ministry of Education in Kuwait asked to send an email explaining the details of the study, thus I have created an email with all the details required.

6. a clear and concise statement of the ethical considerations raised by the project and how you intend to deal with then:
This project is promising to respect the information and the participants by being honest and avoid any possible harm to both researcher and participants. Additionally, this project will ensure that any undertaken research is within the law by following the university of Reading code of good practice in research (UKRIO Code). To conduct the study, I need to get permission to collect the data and working in the field. The permission to conduct this study will be obtained from the Ethics Committee of the university of Reading and the Ministry of Education in Kuwait. This research will be conducted with children, thus the research ethics will be all circulated around ensuring the safety and avoiding harm for the children. Moreover, consent forms are critical point of research ethics, as this research participants are children in schools three consent forms should be established (for school's head teaches, for parents, for children) with written guarantee of confidentiality and anonymity. My supervisors and I are the only persons who will access the recorded data from the experiment, observations and interviews. These recorded will be deleted once the research finished. To ensure participants comfortability and safety, they have the right to

withdraw at any stage of the research. In addition, all research process will be conducted in school environment with knowledge of locating the time. 7. estimated start date and duration of project: the estimated starting date of the project will be in beginning of March until the end of April.	
B: I consider that this project **may** have ethical implications that should be brought before the Institute's Ethics Committee.	
Please state the total number of participants that will be involved in the project and give a breakdown of how many there are in each category e.g. teachers, parents, pupils etc.	
Give a brief description of the aims and the methods (participants, instruments and procedures) of the project in up to 200 words. 1. title of project 2. purpose of project and its academic rationale 3. brief description of methods and measurements 4. participants: recruitment methods, number, age, gender, exclusion/inclusion criteria 5. consent and participant information arrangements, debriefing (attach forms where necessary) 6. a clear and concise statement of the ethical considerations raised by the project and how you intend to deal with then. 7. estimated start date and duration of project	

C: SIGNATURE OF APPLICANT:

Note: a signature is required. Typed names are not acceptable.

I have declared all relevant information regarding my proposed project and confirm that ethical good practice will be followed within the project.

Signed: …………Fatma……… Print Name…Fatemah Almuwaiziri………………….. Date 02-02-2018…………

STATEMENT OF ETHICAL APPROVAL FOR PROPOSALS SUBMITTED TO THE INSTITUTE ETHICS COMMITTEE

This project has been considered using agreed Institute procedures and is now approved.

Signed: ….[redacted]…………… Print Name……Jill Porter. Date……15/3/18.
(IoE Research Ethics Committee representative)*

* A decision to allow a project to proceed is not an expert assessment of its content or of the possible risks involved in the investigation, nor does it detract in any way from the ultimate responsibility which students/investigators must themselves have for these matters. Approval is granted on the basis of the information declared by the applicant.

2. Pilot Study Plan

The aim of the pilot study is to test the feasibility of applying the study instruments. In addition, it can help evaluate the tools being used to examine both passively received visualisation (PRV) and self-constructed visualisation (SCV). PRV is when children use given images of objects to help visualise word problems, whereas SCV is when children create their own images and drawings to visualise word problems. Children will use two different apps to assist them during the PRV and SCV phases. Furthermore, the pilot study will provide an understanding of the suitability of the research tools on children. Thus, the pilot test sample will include students from the same schools (schools for children with learning disabilities) and of the same age as the main study's participants, but with a non-ADHD learning difficulty. The students will be randomly selected to participate in the pilot study. The sample size will be two students from girls' schools and two students from boys' school. Conducting the pilot study in the same schools helps me gain a better understanding of these schools' environments, gives me the opportunity to conduct the study with other students with learning disabilities, and facilitates the process of getting consent forms for the main study.

The pilot study will follow the same steps as the main study for each student. If it is possible to carry it out this semester, it will be conducted in April; otherwise, it will be conducted in September (the beginning of the new academic year). The pilot study will last 7 days according to the following schedule:

- Day One: Conduct pre-test and pre-test interview questions
- Day Two: Apply SCV or PRV (students will be randomly allocated to the phases)
- Day Three: Apply SCV or PRV (students will be randomly allocated to the phases)
- Day Four: Apply PRV or SCV (students will be randomly allocated to the phases)
- Day Five: Apply PRV or SCV (students will be randomly allocated to the phases)
- Day Six: Conduct post-test and post-test interview questions
- Day Seven: Spare day in case any implications arise during the pilot study

Observations of each student will be conducted via a video recording during the experiment part, similar to the observation of the main study, but for a shorter period. All these study steps will be addressed in more detail below.

First, the interview questions will be the same questions as the main study interview questions, as is clarified in the tables below. The semi-structured interview questions in Table 1 will be conducted for each participant before starting the experiment to understand how the participants deal with mathematical word problems in general before carrying out the PRV and SCV phases. This interview will take place after the pre-test and will take between 15 and 30 minutes; all interviews will be video recorded because of questions 1 and 2.

Table 1

Pre-test Interview Questions

Questions	**Theories**
How did you find the test? Why?	
If I give you this word problem (I will give the student a paper with a written word problem on it) what is the first thing that comes to your mind to solve this problem?	Representation (Bruner, 1966), conceptual understanding (Kilpatrick, Swafford, & Findell, 2001)
Using the same word problem (written on the paper), can you explain how you would solve it?	Intelligent learning or relational understanding (Skemp, 1989), procedure fluency (Kilpatrick et al., 2001)
Did you use the same strategy on the test?	
When you did the test with me, how did you solve the problems on the test?	Intelligent learning or relational understanding (Skemp, 1989), procedure fluency (Kilpatrick et al., 2001)
Do you like to use technology in your everyday school activities?	
If you have the freedom not use apps, would you do so? Or do you prefer to use them?	

The semi-structured interview questions in Table 2 will be applied for each participant after the experiment intervention has finished to understand if the students successfully used the research tools. In addition, these interviews will try to address the students' perceptions in order to understand how they learn mathematical word problems by using PRV and SCV. These interviews will take place after the post-test and will last between 15 and 30 minutes; they will be video recorded because of questions 1 and 2.

Table 2

Post-test Interview Questions

Questions	Theories
Did you like using the apps to solve the mathematical word problems? If not, why?	
In the past four sessions with me, you used two different apps. If I give you this word problem (I will give the student a paper with a written word problem in it), what is the first thing that comes to your mind to solve this problem?	Representation (Bruner, 1966), conceptual understanding (Kilpatrick et al., 2001)
For the same word problem (written on the paper), can you explain how you will solve it?	Intelligent learning or relational understanding (Skemp, 1989), procedure fluency (Kilpatrick et al., 2001)
When you did the test with me, how did you solve the exam problems?	Intelligent learning or relational understanding (Skemp, 1989), procedure fluency (Kilpatrick et al., 2001)
Did you refer to the apps in your mind while doing the test with me? If yes, how? What happened exactly?	Representation (Bruner, 1966)
While doing the test with me, which app did you refer to most? Why?	Conceptual understanding (Kilpatrick et al., 2001)
How has using the apps in the last four sessions helped you solve the word problems?	Representation (Bruner, 1966)
Would you ask your teacher to use these apps in the mathematics class?	
Would you ask your parent to download a similar app as the ones we have used in the last four sessions for you to use to learn mathematical word problems?	
If you have the freedom not to use the apps to learn mathematical word problems, would you do so? Or do you prefer to use them?	

The experiment sessions plan and the tests for each participant student will be carried out as follows:

- Each student will participate in a daily one-to-one session for a maximum of 30 minutes for 4 days. The study will be conducted in special schools for students with learning disabilities. These schools have a different system than other government schools. The normal school practice is that classes are divided into two types: a group class, where students are taught with their peers by their class teacher following the Ministry of Education curriculum plan, and one-to-one sessions, where students work one-on-one with their teacher to develop their skills and knowledge and follow up with the curriculum plan. As the research does not want to interrupt the group lessons, she will conduct the research experiment during the one-to-one sessions.
- Further instructions will only be given when the student asks for some clarification.
- The test questions will be taken from the authoritative files for test questions from the selected schools of the study. The test questions will be chosen with the help of teachers working with students in the same age range selected for the current research. These test questions will be somewhat similar, but the structure will be different. The tests are:

    - Pre-test: given before the beginning of the first session, it will contain 10 questions.
    - After every two sessions, the student will be given a test of 10 questions to determine the extent of the development of using SCV and PRV.
    - Post-test: given after completing all the sessions.

- During the experiment the phases will be changed for each student, where each student will test both PRV and SCV for different periods of time. The students will be selected randomly for each phase in the beginning of the experiment.

Table 3

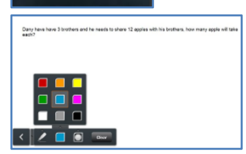
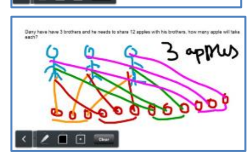
Example of the experimental design

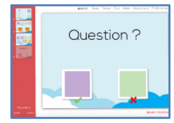
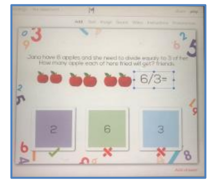
	Week 1	
Child	First 2 sessions (Days 1 and 2)	Second 2 sessions (Days 3 and 4)
A	SCV	PRV
B	PRV	SCV
C	SCV	PRV
D	PRV	SCV

The same apps as the main study will be used, as shown in Table 4.

Table 4

Apps used in the study

Visualization methods	Name of app	Description of app	Web link to app	Example of app
SCV	SlideShark Presentation	This app can allow the teachers to design their presentation and upload it in SlideShark through different ways, such as BoX, Dropbox, OneDrive, ShareFile, Syncplicity, and Google Drive. This app provides the tools for drawing and writing when solving the problems. It can also save the students' work. This app does not provide a final report on right and wrong answers.	https://itunes.apple.com/us/app/slideshark-presentation-app/id471369684?mt=8 Privacy Policy: https://www.brainshark.com/company/privacy-policy	  

PRV	Make It	This app allows teachers to design their own lessons using objects, images, sound, videos and instructions. This app gives the option to save the work, but it does not provide a final report on right and wrong answers.	https://itunes.apple.com/us/app/make-it-for-teachers/id1182354738?mt=8 Privacy Policy: http://www.planetfactory.com/textos/avis Terms of Service: http://www.planetfactory.com/textos/tos Email: makeit@planetfactory.com	 

Observations are necessary to understand to what extent PRV and SCV can affect the behaviour and focus of students with ADHD while solving mathematical word problems. The observation sheet (see Table 5) was developed from the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5) for 4 sessions for each child. The observations will be collected from the recorded video for each student during the experiment. Each observation will indicate the occurrence of the ADHD behaviour. If the behaviour occurs, the researcher will put 1; if it does not, the researcher will put 0.

Table 5

Observation Sheet

Week 1	**Sessions**			
ADHD behaviour	1	2	3	4
1-Inattention				
Missing details and the work is inaccurate				
Difficulties remaining focused on tasks				
Mind seems elsewhere				
Easily distracted				
Difficulties organising the task				
Avoids engagement in tasks				
Forgets daily activities				
2-Hyperactivity and Impulsivity				
Taps hands or feet				
Squirms in the seat				
Often leaves the seat, does not remain seated				
Runs or climbs in inappropriate situations				
Uncomfortable remaining still for an extended time				
Talks excessively				

University of Reading

3. Children's Pilot Study Consent Form

Note: This form is for young children. The statements are read, and the child colours the face to indicate consent or not.

Miss Fatemah has told me about the reason for the maths lessons.

Miss Fatemah has answered the questions I have had about the maths lessons.

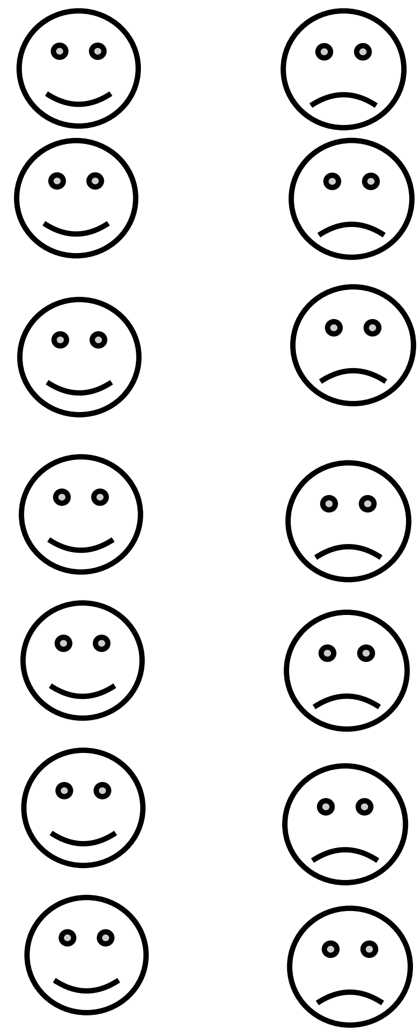
I know that I will be telling Miss Fatemah how I feel about maths and answering questions.

I am happy that Miss Fatemah is using my work for her project.

I understand what the study is about.

I understand that I don't have to take part and can drop out of the study at any time.

I agree to take part in this study



My Name: ……………………………………………………………..

Date: ……………………………………..

University of Reading

4. Head Teachers' Pilot Study Information Sheet

Research Project: Solving mathematical word problems using passively received visualisation (PRV) and self-constructed visualisation (SCV): The case of primary school students with attention deficit hyperactivity disorder (ADHD) in Kuwait.
Researcher's Name: Mrs Fatemah Almuwaiziri
Research Supervisors: Dr Natthapoj Vincent Trakulphadetkrai; Dr Tim Williams

Dear Head Teacher

We are writing to invite your school to take part in a pilot study about learning mathematical word problems.

What is the study?

A few weeks ago, I contacted you about a study I am conducting at the University of Reading as part of my PhD research. The study aims to help students with ADHD accessing mathematical word problems by using passively received visualisation (PRV) and self-constructed visualisation (SCV). PRV is when children use given images of objects to help visualise word problems, whereas SCV is when children create their own images and drawings to visualise word problems. Children will use two different apps to assist them during the PRV and SCV phases. I hope to use the findings to make recommendations regarding how we can best help learners make progress in mathematical learning and best prepare ADHD students' understanding of mathematical word problems while developing their abilities to solve word problems. Before conducting the main study, a pilot study will take place. The aim of the pilot study is to test the feasibility of applying the study instruments. It will also help evaluate the tools being used to examine both PRV and SCV.

Why has this school been chosen to take part?

Following our previous letter, you kindly expressed an interest in participating in the project. In addition, your school is being invited to take part in the project because it is a special school for students with learning disabilities where the main study will be conducted. In addition, as a former teacher of one of these schools, I have seen how these schools, in their teaching of mathematics, face problems teaching mathematical word problems for students with ADHD.

Does the school have to take part?

It is entirely up to you whether you give permission for the school to participate. You may also withdraw your consent to participate at any time during the project, without any repercussions to you, by contacting me, the researcher, Fatemah Almuwaiziri (Tel: +44(0)7727001555, email: zs885101@live.reading.ac.uk).

What will happen if the school takes part?

With your agreement, participation would involve me administering a mathematical word problem tasks to your learners in the Year 4 and 5 classes; these learners will have daily one-to-one sessions with me for a maximum of 30 minutes for 1 week. Your students will complete a brief (10-item) word problems pre-test in mathematics and an interview (lasting 15 to 30 minutes) before the first session of the project. All project activities will be video recorded. After every two sessions, the student will be given a test of 10 questions to determine any progression in using SCV and PRV. A post-test will be administered after completing all sessions, along with another interview lasting 15 to 30 minutes. The tests questions will be taken from the authoritative files of the test questions from the selected schools of the study. The test questions will be chosen with help of the teachers working with students of the same age range selected for the current research. These test questions will be somewhat similar, but the structure will be different.

Furthermore, an observation sheet based on the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5) will be used with the video recordings while applying the experiment. This sheet will track changing ADHD behaviours in terms of inattention (7 categories) and hyperactivity/impulsivity (6 categories) while using PRV and SCV in mathematic lessons for word problems. The main goal is to see if these categories occur when using PRV and SCV with students with ADHD during the 4 sessions and to determine if this observation is effective for use in the main study.

Finally, so that I can set your students' learning of mathematics into context, I would also like your permission for their current school to share details of their attainment on the mathematics report. I will conduct the sessions and am fully CRB checked.

If you agree to the school's participation, I will seek further consent from parents/carers and the children themselves.

What are the risks and benefits of taking part?

The information given by participants in the study will remain confidential and will only be seen by the research team listed at the start of this letter. Neither you, the children, nor the school will be identifiable in any published report resulting from the study. Information about individuals will not be shared with the school. Participants in similar studies have found it interesting to take part. I anticipate that the findings of the study will be useful for teachers in planning how they teach mathematical word problems.

What will happen to the data?

Any data collected will be held in strict confidence, and no real names will be used in this study or in any subsequent publications. The records of this study will be kept private. No identifiers linking you, the children, or the school to the study will be included in any sort of report that might be published. Participants will be assigned a number and will be referred to by that number in all records. Research records will be stored securely in a locked filing cabinet and on a password-protected computer, and only the research team will have access to the records. In line with the University of Reading's policy on the management of research data, anonymised data gathered in this research may be preserved and made publicly available for others to consult and re-use. The results of the study will be presented at national and international conferences and in written reports and articles. I can send you electronic copies of these publications, if you wish.

What happens if I change my mind?

You can change your mind at any time without any repercussions. If you change your mind after data collection has ended, I will discard the school's data.

What happens if something goes wrong?

In the unlikely case of a concern or complaint, you can contact me, the researcher (Fatemah Almuwaiziri, Tel: +44(0)7727001555, email: zs885101@live.reading.ac.uk).

Where can I get more information?

If you would like more information, please contact me.

This project has been reviewed following the procedures of the University Research Ethics Committee and has been given a favourable ethical opinion for conduct. The University of Reading has the appropriate insurances in place. Full details are available on request.

I do hope that you will agree to your school's participation in the study. If you do, please complete the attached consent form and return it by email it to me at: zs885101@live.reading.ac.uk.

Thank you for your time.

Yours sincerely,

5. Head Teachers' Pilot Study Consent Form

I have read the Information Sheet about the project and received a copy of it.

I understand what the purpose of the project is and what is required of me. All my questions have been answered.

Name of Head Teacher: ____

Name of primary school: _______________________________________

Please tick as appropriate:

I consent to the involvement of my school in the project as outlined in the Information Sheet ☐

Signed: ____________________________

Date: ________________________________

6. Parents'/Carers' Pilot Study Information Sheet

Research Project: Solving mathematical word problems using passively received visualisation (PRV) and self-constructed visualisation (SCV): The case of primary school students with attention deficit hyperactivity disorder (ADHD) in Kuwait.
Researcher Name: Mrs Fatemah Almuwaiziri
Research Supervisors: Dr Natthapoj Vincent Trakulphadetkrai; Dr Tim Williams

We would like to invite your child to take part in a research study about learning mathematical word problems.

What is the study?

The study is being conducted by the University of Reading as PhD research. The study aims to help students with ADHD access mathematical word problems by using passively received visualisation (PRV) and self-constructed visualisation (SCV). PRV is when children use given images of objects to help visualise word problems, whereas SCV is when children create their own images and drawings to visualise word problems. Children will use two different apps to assist them during the PRV and SCV phases. The researcher hopes to use the findings to make recommendations regarding how we can best help learners make progress in mathematical learning and how we can best prepare ADHD students for understanding mathematical word problems while developing their abilities in solving word problems. Before conducting the main study, a pilot study will take place. The aim of the pilot study is to test the feasibility of applying the study instruments. In addition, it can help evaluate the tools used to examine both PRV and SCV.

Why has my child been chosen to take part?

Your child has been invited to take part in the project because his/her mathematics teacher and school have expressed an interest in being involved in our project. All learners who are taught mathematics by her/his primary school in Years 4 and 5 are being invited to take part.

Does my child have to take part?

It is entirely up to you whether your child participates. You may also withdraw your consent to participate at any time during the project, without any repercussions to you or your child, by contacting the project researcher, Mrs Fatemah Almuwaiziri (Tel: +44(0)7727001555, email: zs885101@live.reading.ac.uk).

What will happen if my child takes part?

With your agreement, participation would involve us administering a mathematical word problem task to learners in the Year 4 and 5 class taught by Mrs Fatemah Almuwaiziri; these learners will have daily one-to-one sessions for a maximum 30 minute for 1 week. Your child will complete a brief (10 questions) word problems pre-test in mathematics and an interview lasting 15 to 30 minutes before the first session of the project. All project activities will be video recorded. After every two sessions, the student will be given a test of 10 questions to determine the extent of the development of SCV and PRV use. A post-test will be given after completing all the sessions, along with an interview lasting 15 to 30 minutes. The test questions will be taken from the authoritative files of the test questions from the selected schools of the study. Test questions will be chosen with the help of teachers of students of the same age range selected for the current research. These test questions will be somewhat similar, but the structure will be different.

Furthermore, an observation sheet based on the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5) will be used with the video-recorded observations while applying the experiment. This sheet will track changing ADHD behaviours in terms of inattention (7 categories) and hyperactivity/impulsivity (6 categories) while using PRV and SCV in mathematic lessons for word problems. The main goal is to see if these categories occur when using PRV and SCV with students with ADHD during the 4 sessions and to determine if this observation is effective for use in the main study.

Finally, so that we can set your child's learning of mathematics into context, we would also like your permission for their current school to share details of their attainment on the mathematics report. The researcher, Mrs Fatemah, who is fully CRB checked, will conduct the sessions.

What are the risks and benefits of taking part?

The information you and your child give will remain confidential and will only be seen by the research team listed at the start of this letter. Neither you, your child, nor the school will be identifiable in any published report resulting from the study. Taking part will in no way influence the grades your child receives at school. Information about individuals will not be shared with the school.

Participants in similar studies have found it interesting to complete the tests and interviews that we will administer. We anticipate that the findings of the study will be useful for teachers in planning how they teach mathematical word problems. An electronic copy of the published findings of the study can be made available to you by contacting the project researcher.

What will happen to the data?

Any data collected will be held in strict confidence, and no real names will be used in this study or in any subsequent publications. The records of this study will be kept private. No identifiers linking you, your child, or the school to the study will be included in any sort of report that might be published. We will transcribe the recordings from the tests and anonymise them before analysing the results. Children will be assigned a number and will be referred to by that number on all audio recordings and in all interviews. Research records will be stored securely in a locked filing cabinet and on a password-protected computer, and only the research team will have access to the records. In line with the University of Reading's policy on the management of research data, anonymised data gathered in this research may be preserved and made publicly available for others to consult and re-use. The results of the study will be presented at national and international conferences and in written reports and articles.

Who has reviewed the study?

This project has been reviewed following the procedures of the University Research Ethics Committee and has been given a favourable ethical opinion for conduct. The University of Reading has the appropriate insurances in place. Full details are available on request.

What happens if I/my child change our mind?

You/your child can change your mind at any time without any repercussions. During the research, your child can stop completing the activities at any time. If you change your mind after data collection has ended, we will discard your/your child's data.

What happens if something goes wrong?

In the unlikely case of a concern or complaint, you can contact the researcher, Mrs Fatemah Almuwaiziri (Tel: +44(0)7727001555, email: zs885101@live.reading.ac.uk).

Where can I get more information?

If you would like more information, please contact the researcher, Mrs Fatemah Almuwaiziri.

We do hope that you will agree to your child's participation in the study and to your involvement in it. If you do, please complete the attached consent form and return it by email to the project researcher at: email: zs885101@live.reading.ac.uk.

Thank you for your time.

7. Parents'/Carers' Pilot Study Consent Form

I have read the Information Sheet about the project and received a copy of it.

I understand what the purpose of the project is and what is required of my child and me. All my questions have been answered.

Name of child: ____

Name of primary school: _______________________________

Please tick as appropriate:

I consent to my child completing the mathematics task and interview ☐

I consent to the school giving the research team details of my child's grades in mathematics and ADHD diagnosis report ☐

I consent to my child completing the mathematical tasks and interview in school ☐

I consent to the video-recording of my child completing the mathematics tasks ☐

I consent to my child completing an interview ☐

To allow the researcher to contact you to after data collection or in a case of publications, please provide the following details:

Name of parent/carer: ____

Parent/carer postal address:

____

____

Parent/carer telephone number (mobile preferred): __________________________

Signed: _____________________________

Date: _________________________________

8. Letter to the Kuwait Ministry of Education: Permission to Conduct the Pilot Study

Dear XXX:

I am writing to request permission to conduct a pilot study at your institution. The aim of the pilot study is to test the feasibility of applying the study instruments. In addition, it can help evaluate the tools being used to examine both passively received visualisation (PRV) and self-constructed visualisation (SCV). PRV is when children use given images of objects to help visualise word problems, whereas SCV is when children create their own images and drawings to visualise word problems. Children will use two different apps to assist them during the PRV and SCV phases. Furthermore, the pilot study will provide an understanding of the suitability of the research tools for children. As the researcher, I hope to make recommendations regarding how we can best help learners make progress in mathematical learning and understand mathematical word problems to develop their abilities in solving word problems.

I hope that you will allow me to recruit a minimum of 4 students from the schools for children with learning disabilities schools (……….. and …………) to be interviewed, observed, and examined while using PRV and SCV. Interested members (parents, headteachers, and students), who volunteer to participate in the pilot study will be given an information sheet and a consent form to be signed and returned to me at the beginning of the pilot study process. The duration of the pilot study is 7 days. It will be carried out in April of this semester, if possible; otherwise, it will be conducted in September (the beginning of the new academic year).

If approval is granted, selected participants will be interviewed, observed, and examined while using PRV and SCV on their own; no costs will be incurred by either your school or the individual participants. All information collected will be kept strictly confidential (subject to legal limitations). In order to protect the anonymity of each participant, pseudonyms will be used to ensure that participants cannot be identified, and individual school names will not be used. All electronic data will be held securely in password-protected files on a non-shared computer, and all paper documentation will be held in locked cabinets in a locked office In line with the University of Reading's policy on the management of research data, anonymised data gathered in this research may be preserved and made publicly available for others to consult and re-use. The data may be used in future publications in appropriate academic journals and/or books. All participants will be able to have access to a copy of the published research on request.

Your approval to conduct this study will be greatly appreciated. If you agree, kindly reply to this email acknowledging your consent and permission for me to conduct this survey/study at your institution.

Yours sincerely,

Fatemah Almuwaiziri

9. Children's Information Sheet

What happens next?

Your parents have been sent a letter asking for their permission for you to take part in this project (pilot study).

We will check with you before we do the tasks that you are happy to help us with our project (pilot study).

If you have any questions, please speak to your class teacher or Mrs Fatemah.

Or you can contact

Mrs Fatemah Almuwaiziri

Zs885101@live.reading.ac.uk

The researcher:

Mrs Fatemah Almuwaiziri

This project has been reviewed following the procedures of the University of Reading Research Ethics Committee and has been given a favourable ethical opinion for conduct.

University of Reading

Institute of Education
London Road Campus
RG1 5EX

Research Project:
Solving mathematical word problems using passively visualisation (PRV) and self-constructed visualisation (SCV): The case of Attention Deficit Hyperactivity Disorder (ADHD) primary school students in Kuwait.

Information Sheet

I am doing a project to help students with ADHD to access mathematical word problems by using visualizations (Apps). I will try to examine and explore how the tools of the project are applicable to the children category and serve the research objectives.

Why have I been invited to take part?

You have been invited to take part because you were randomly selected for this pilot study and your teacher and parent are interesting in this project

What will I have to do if I agree to take part?

We will give you a daily one-to-one sessions for one weeks which are in total 4 sessions by using apps to learn mathematic word problems. And these sessions will be video recorded.

We will also ask you to answer interview questions, about how you feel about learning mathematical word problems, when you are using apps.

Will anyone know about my answers?

Only the people working on the project will know about your answers. We won't tell your school how you answered, or your parents.

Will it help me if I take part?

We think you will find it interesting and fun to do the mathematical word problems by using apps. Your answers will help your teachers to know the best ways to teach mathematics word problems. in addition your answers will help the researcher to understand if the project tools are applicable or not.

Do I have to take part?

No, not at all. Also, you can stop helping us with our project at any time, without giving a reason. Just ask your teacher or your parents to tell us if you want to stop.

10. Ethical Approval for Main Study

University of Reading
Institute of Education
Ethical Approval Form A (version May 2015)

Tick one:

Staff project: _____ (PhD) ___ EdD ____

Name of applicant (s): Fatemah Almuwaiziri

Title of project: Solving mathematical word problems using passively visualisation (PRV) and self-constructed visualisation (SCV): The case of Attention Deficit Hyperactivity Disorder (ADHD) primary school students in Kuwait.

Name of supervisor (for student projects): Natthapoj Vincent Trakulphadetkrai

Please complete the form below including relevant sections overleaf.

	YES	NO	
Have you prepared an Information Sheet for participants and/or their parents/carers that:			
a) explains the purpose(s) of the project	X		
b) explains how they have been selected as potential participants	X		
c) gives a full, fair and clear account of what will be asked of them and how the information that they provide will be used	X		
d) makes clear that participation in the project is voluntary	X		
e) explains the arrangements to allow participants to withdraw at any stage if they wish	X		
f) explains the arrangements to ensure the confidentiality of any material collected during the project, including secure arrangements for its storage, retention and disposal	X		
g) explains the arrangements for publishing the research results and, if confidentiality might be affected, for obtaining written consent for this	X		
h) explains the arrangements for providing participants with the research results if they wish to have them	X		
i) gives the name and designation of the member of staff with responsibility for the project together with contact details, including email. If any of the project investigators are students at the IoE, then this information must be included and their name provided	X		
k) explains, where applicable, the arrangements for expenses and other payments to be made to the participants		X	
j) includes a standard statement indicating the process of ethical review at the University undergone by the project, as follows: 'This project has been reviewed following the procedures of the University Research Ethics Committee and has been given a favourable ethical opinion for conduct'.	X		
k)includes a standard statement regarding insurance: "The University has the appropriate insurances in place. Full details are available on request".	X		
Please answer the following questions			
1) Will you provide participants involved in your research with all the information necessary to ensure that they are fully informed and not in any way deceived or misled as to the purpose(s) and nature of the research? (Please use the subheadings used in the example information sheets on blackboard to ensure this).	X		
2) Will you seek written or other formal consent from all participants, if they are able to provide it, in addition to (1)?	X		
3) Is there any risk that participants may experience physical or psychological distress in taking part in your research?		X	
4) Have you taken the online training modules in data protection and information security (which can be found here: http://www.reading.ac.uk/internal/imps/Staffpages/imps-training.aspx)?	X		
5) Have you read the Health and Safety booklet (available on Blackboard) and completed a Risk Assessment Form to be included with this ethics application?	X		
6) Does your research comply with the University's Code of Good Practice in Research?	X		
	YES	NO	N.A.

7) If your research is taking place in a school, have you prepared an information sheet and consent form to gain the permission in writing of the head teacher or other relevant supervisory professional?	X		
8) Has the data collector obtained satisfactory DBS clearance?	X		
9) If your research involves working with children under the age of 16 (or those whose special educational needs mean they are unable to give informed consent), have you prepared an information sheet and consent form for parents/carers to seek permission in writing, or to give parents/carers the opportunity to decline consent?	X		
10) If your research involves processing sensitive personal data[1], or if it involves audio/video recordings, have you obtained the explicit consent of participants/parents?	X		
11) If you are using a data processor to subcontract any part of your research, have you got a written contract with that contractor which (a) specifies that the contractor is required to act only on your instructions, and (b) provides for appropriate technical and organisational security measures to protect the data?			X
12a) Does your research involve data collection outside the UK?	X		
12b) If the answer to question 12a is "yes", does your research comply with the legal and ethical requirements for doing research in that country?	X		
13a) Does your research involve collecting data in a language other than English?	X		
13b) If the answer to question 13a is "yes", please confirm that information sheets, consent forms, and research instruments, where appropriate, have been directly translated from the English versions submitted with this application.	X		
14a. Does the proposed research involve children under the age of 5?		X	
14b. If the answer to question 14a is "yes": My Head of School (or authorised Head of Department) has given details of the proposed research to the University's insurance officer, and the research will not proceed until I have confirmation that insurance cover is in place.			X
If you have answered YES to Question 3, please complete Section B below			

Please complete **either** Section A **or** Section B and provide the details required in support of your application. Sign the form (Section C) then submit it with all relevant attachments (e.g. information sheets, consent forms, tests, questionnaires, interview schedules) to the Institute's Ethics Committee for consideration. Any missing information will result in the form being returned to you.

A: My research goes beyond the 'accepted custom and practice of teaching' but I consider that this project has **no** significant ethical implications. (Please tick the box.)	X
Please state the total number of participants that will be involved in the project and give a breakdown of how many there are in each category e.g. teachers, parents, pupils etc. approximately a minimum of 3 males and 3 females ADHD will be invited to participate in this study in Kuwaiti primary schools.	
Give a brief description of the aims and the methods (participants, instruments and procedures) of the project in up to 200 words noting: 1. title of project: Research Project (Title): Solving mathematical word problems using passively visualisation (PRV) and self-constructed visualisation (SCV): The case of Attention Deficit Hyperactivity Disorder (ADHD) primary school students in Kuwait. 2. purpose of project and its academic rationale: The study aims to help students with ADHD accessing mathematical word problems by using: passively received visualisation (PRV) and self-constructed visualisation (SCV). PRV is when children use given images of objects to help visualise word problems, whereas SCV is when children create their own images and drawings to visualise word problems. Children will use two different apps to assist them during the PRV and SCV phases. It hopes to make recommendations regarding how we can best help learners to make progress in mathematical learning, and how we can best prepare ADHD students understanding mathematical word	

[1] Sensitive personal data consists of information relating to the racial or ethnic origin of a data subject, their political opinions, religious beliefs, trade union membership, sexual life, physical or mental health or condition, or criminal offences or record.

problems and develop their abilities in solving word problems.

3. brief description of methods and measurements:
To answer the first research question (To what extent do passively received visualisation (PRV) and self-constructed visualisation (SCV) help ADHD students solve mathematics word problems?) two methods will be used. First, a single-case experimental design will be used by applying multiple base line design. The current study is designed to have a daily one-to-one session last for maximum 30 minutes for 25 sessions in total. In each session the student will solve 6-word problems. After each 5 sessions, the student will be tested. The test will include 6-word problems which will be solve in 15 minutes. For the current study, the students will be randomly allocated in a design that involves two groups of students: students using (PRV) the control group and students using (SCV) the intervention group. Furthermore, pre-test will be applied before the beginning of the first session to underline the student's mathematical level. The students will be allocated in to the groups (SCV and PRV) depend on the pre-test score (high, mid and low), where each group will contain students with (high, mid and low) score. The students in both group (control and intervention) will use both apps for SCV and PRV for the same length of time (5 weeks equivalent to 25 sessions). This will demonstrate the effect of using SCV to solve mathematical word problems for each ADHD student. The intervention group will have 15 min introductory session before starting the intervention sessions. The main objectives of the introductory session are to make sure that the students understand what creating or constructing drawing means and to solve any confusion regarding of using the instrument. In the end of the experiment (after the last session) a post- test will be applied to evaluate student's development by using PRV and SCV. The tests questions will be taken from the reliable tests files questions from the selected schools of the study. The choice of the test questions will be done with help of the teachers of the same age range selected for the current research. These tests questions will be somewhat similar, but the structure will be different.

Second, a qualitative observation will be conducted during the experimental sessions (5 sessions per week for 5 weeks) in order to understand how deal and Apply SCV and PRV. The qualitative observation will be applied through an open observation by notes taking to comprehend to some extend how the students solved the mathematics word problem by using PRV and SCV. For example, for PRV sessions the observation notes was about if the students understand the given pictures, did they look using the given picture, the kind of the questions they did ask during the sessions, did they just guess the answers or they really solve it and did they solve the problem correctly. In SCV sessions the observations note mostly about what kind of questions did they asked, how they started solving the problems, what the first step they follow, what type of drawing they great, the quality of drawing, what comments they made or asked and did they solve the problems correctly.

To answer the second research problem (To what extent do PRV and SCV help ADHD students remain focused while solving mathematics word problems?), structured observation will be used (quantitative observation) by following scheduled categories that shape the observation in counting the events. The observation is established to observe ADHD changing behaviour in (Inattentions) and (Hyperactive and Impulsivity) while using PRV and SCV through 25 sessions for mathematic word problems. Observing inattentions is divided in to 7 categories and hyperactive and impulsivity is divided to 6 categories. The observation sheet is developed from DSM-5 (Diagnostic and statistical manual of mental disorders) for 25 sessions for each child. Where each child will have daily one-to-one session for maximum 30 minutes. The observations will be collected from a video recorded for each student during the experiment. These observations will indicate the occurrence of the ADHD behaviour. If the behaviour accrue I will put (1), if not accrue I will put (0).

Students interviews will be used to answer the third research questions (What are ADHD children's perceptions on using PRV and SCV to solve mathematics word problems?). Using semi-structured interviews will provide more information about how students with ADHD learn through applying PRV and SCV by using reflections of interviewee views (students). Each child will be interviewed separately twist. First, for at least 13 to 15 minutes before the first session started. This to understand their general abilities to solve mathematic word problems, and if they prefer to use technology (e.g. apps) to solve mathematical problems. The second interviews will take place after the post-test. The interviews questions can take time between 17 to 20 minutes, each question in both interviews might take time between 1 to 3 minutes depend on the nature of the question and the speed of responding. The interviews will be held in safe environment (the schools) at school time. These interviews will be video recorded and transcribed. The transcript will be translated from Arabic to English by using translator.

4. participants: recruitment methods, number, age, gender, exclusion/inclusion criteria:
approximately a maximum of 20 males and 15 females age 9 to 11 years old will be invited to participate in this study. The students will be randomly distributed in to the intervention group (SCV) and control grope (PRV) depend on the pre-test score (high, mid, and low), where each group will have students with (high, mid, and low) score.

5. consent and participant information arrangements, debriefing (attach forms where necessary):
As this study will be applied in schools, three types of consent form are needed. First, I need a consent form

for the head teacher of each school with information sheet to clarify the natural of study will be held in their schools. Second, I need to develop a consent and information sheet for the parents. This to give a clear idea for the parents about what their children will be involve in, why their children have been chosen, and what are their right. Finally, the child has the right to understand what they are involve in, and their rights as apart of the project. Thus, I developed and information sheet and consents form for the students. As Ministry of Education in Kuwait asked to send an email explaining the details of the study, thus I have created an email with all the details required.

6. a clear and concise statement of the ethical considerations raised by the project and how you intend to deal with then:
   This project is promising to respect the information and the participants by being honest and avoid any possible harm to both researcher and participants. Additionally, this project will ensure that any undertaken research is within the law by following the university of Reading code of good practice in research (UKRIO Code). To conduct the study, I need to get permission to collect the data and working in the field. The permission to conduct this study will be obtained from the Ethics Committee of the university of Reading and the Ministry of Education in Kuwait. This research will be conducted with children, thus the research ethics will be all circulated around ensuring the safety and avoiding harm for the children. Moreover, consent forms are critical point of research ethics, as this research participants are children in schools three consent forms should be established (for school's head teaches, for parents, for children) with written guarantee of confidentiality and anonymity. My supervisors and I are the only persons who will access the recorded data from the experiment, observations and interviews. These recorded will be deleted once the research finished. To ensure participants comfortability and safety, they have the right to withdraw at any stage of the research. In addition, all research process will be conducted in school environment with knowledge of locating the time.

7. estimated start date and duration of project:
   the estimated starting date of the project will be in beginning of March until the end of April.

B: I consider that this project **may** have ethical implications that should be brought before the Institute's Ethics Committee.	

Please state the total number of participants that will be involved in the project and give a breakdown of how many there are in each category e.g. teachers, parents, pupils etc.

Give a brief description of the aims and the methods (participants, instruments and procedures) of the project in up to 200 words.

1. title of project
2. purpose of project and its academic rationale
3. brief description of methods and measurements
4. participants: recruitment methods, number, age, gender, exclusion/inclusion criteria
5. consent and participant information arrangements, debriefing (attach forms where necessary)
6. a clear and concise statement of the ethical considerations raised by the project and how you intend to deal with then.
7. estimated start date and duration of project

C: SIGNATURE OF APPLICANT:

Note: a signature is required. Typed names are not acceptable.

I have declared all relevant information regarding my proposed project and confirm that ethical good practice will be followed within the project.

Signed: …………*Fatma*……… Print Name…Fatemah Almuwaiziri……………………. Date 20-07-2018……………

STATEMENT OF ETHICAL APPROVAL FOR PROPOSALS SUBMITTED TO THE INSTITUTE ETHICS COMMITTEE

This project has been considered using agreed Institute procedures and is now approved.

Signed: [redacted] … Print Name………Jill Porter……. Date…27/7/18….
(IoE Research Ethics Committee representation

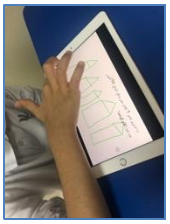
* A decision to allow a project to proceed is not an expert assessment of its content or of the possible risks involved in the investigation, nor does it detract in any way from the ultimate responsibility which students/investigators must themselves have for these matters. Approval is granted on the basis of the information declared by the applicant.

11. Introductory Session

The main objectives of the introductory session are to make sure that the students understand what creating or constructing a drawing means and to resolve any confusion regarding using the instrument. This session will only include the intervention group that use self-constructed visualization (SCV), which is when children create their own images and drawings to visualise word problems. The control group will not need this session because they will use passively received visualization (PRV), which is when children use given images of objects to help visualise word problems.

The introductory session will be delivered after the pre-test and the pre-test interviews. The students will be allocated into the groups (SCV and PRV), depending on the pre-test score (high, mid, or low), with each group containing students with high, mid, and low scores. The students in both groups (control and intervention) will use both apps for SCV and PRV for the same length of time (5 weeks, equivalent to 25 sessions). The introductory session will be conducted before the first intervention session and will last 10 to 15 minutes. Some aspects that can be discussed in the introductory session include:

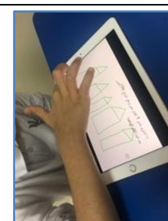
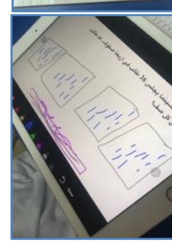
- What does ‘creating a drawing’ mean?
- What kind of drawing should the students create?
- To what extent should the students’ drawing provide a translation for the word problem?
- How can students draw using the Keynote app?

Visualization methods	Name of app	Description of app	Web link of app	Example of app
SCV	Keynote	This app can allow teachers to design their presentation and upload it in slides through different ways, such as BoX, Dropbox, OneDrive, ShareFile, Syncplicity, and Google Drive. This app provides the tools for drawing and writing when solving problems. It can also save the students' work. This app does not provide a final report of right and wrong answers.	https://www.apple.com/uk/iwork/keynote/ Privacy Policy: https://www.apple.com/uk/privacy/	  

12. Qualitative Observation

A qualitative observation will be conducted during the experimental sessions (5 sessions per week for 5 weeks) in order to understand how to use and apply self-constructed visualization (SCV), where children create their own images and drawings to visualise word problems, and passively received visualization (PRV), where children use given images of objects to help visualise word problems. Children will use two different apps to assist them during the PRV and SCV phases. The Keynote app will be used for SCV, and the Make It app will be used for PRV (see Table 1).

Table 1: SCV and PRV apps

Visualization method	Name of app	Description of app	Web link of app	Example of app
SCV	Keynote	This app can allow teachers to design their presentation and upload it in slides through different ways, such as BoX, Dropbox, OneDrive, ShareFile, Syncplicity, and Google Drive. This app provides the tools for drawing and writing when solving problems. It can also save the students' work. This app does not provide a final report of right and wrong answers.	https://www.apple.com/uk/iwork/keynote/ Privacy Policy: https://www.apple.com/uk/privacy/	  

PRV	Make It	This app allows teachers to design their own lessons using objects, images, sound, videos, and instructions. This app gives the option to save the work, but it does not provide a final report of right and wrong answers.	https://itunes.apple.com/us/app/make-it-for-teachers/id1182354738?mt=8 Privacy Policy: http://www.planetfactory.com/textos/avis Terms of Service: http://www.planetfactory.com/textos/tos Email: makeit@planetfactory.com	

Qualitative observation will be applied through open observation by taking notes to comprehend the extent to which students solved the mathematical word problem by using PRV and SCV. These notes taken based on the ideas outlined in Table 2.

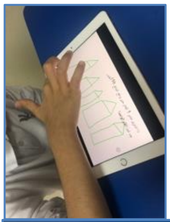
Table 2: Notes for SCV and PRV

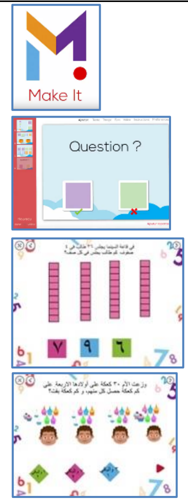
Visualization	Areas observed
SCV	• The kinds of questions students asked • How they started solving the problems • The first step that they took • The type of drawing they created • The quality of the drawing • Comments they made or asked • Did they solve the problems correctly?
PRV	• If the students understood the given images • Did they look using the given images? • The kinds of questions asked during the sessions • Did they guess the answers or solve the problem? • Did they solve the problem correctly?

13. Plan of Experimental Sessions

Kuwait's curriculum plan is divided into two semesters; the first semester runs from September to December, and second semester runs from January to May. The study will be conducted in the first semester and will be applied in special schools for students with learning disabilities. These schools have a different system than other government schools. The classes in these schools are divided into two different types: group classes, in which students are taught with their peers following the Ministry of Education curriculum plan, and one-to-one sessions, in which students meet one-to-one with their teacher to develop their skills and knowledge to follow up with the curriculum plan. The study aims to help students with ADHD accessing mathematical word problems by using passively received visualisation (PRV) and self-constructed visualisation (SCV). PRV is when children use given images of objects to help visualise word problems, whereas SCV is when children create their own images and drawings to visualise word problems. Children will use two different apps to assist them during the PRV and SCV phases: the Keynote app for SCV and Make It app for PRV (see Table 1).

Table 1: SCV and PRV apps

Visualization method	Name of app	Description of app	Web link of app	Example of app
SCV	Keynote	This app can allow teachers to design their presentation and upload it in slides through different ways, such as BoX, Dropbox, OneDrive, ShareFile, Syncplicity, and Google Drive. This app provides the tools for drawing and writing when solving problems. It can also save the students' work. This app does not provide a final report of right and wrong answers.	https://www.apple.com/uk/iwork/keynote/ Privacy Policy: https://www.apple.com/uk/privacy/	  

PRV	Make It	This app allows teachers to design their own lessons using objects, images, sound, videos, and instructions. This app gives the option to save the work, but it does not provide a final report of right and wrong answers.	https://itunes.apple.com/us/app/make-it-for-teachers/id1182354738?mt=8 Privacy Policy: http://www.planetfactory.com/textos/avis Terms of Service: http://www.planetfactory.com/textos/tos Email: makeit@planetfactory.com	

The researcher does not want to interrupt the group lessons; thus, the researcher will apply the research experiment during the one-to-one sessions. In addition, the researcher is very aware of the importance of applying the research to suit the school curriculum plan. For example, the study will be conducted during the autumn term, and the sessions will be about multiplication and division word problems. Furthermore, the researcher does not wish to add an extra load to the class teacher; therefore, the researcher will implement the study.

The experiment sessions plan for the participants students will be as follows:

- Each student will take a daily one-to-one session for a maximum of 30 minutes and 6 questions for each session. The current study is designed so that each student will experience five phases of the intervention and five phases of the control (5 weeks, with each week containing 5 sessions as one phase) to examine the effects of SCV and PRV in helping ADHD students learn to solve mathematical word problems.
- The students will be allocated into the groups (SCV and PRV) depending on the pre-test score (high, mid, and low), where each group will contain students with high, mid, and low scores. The students in both groups (control and intervention) will use both apps for SCV and PRV for the same length of time (5 weeks, equivalent to 25 sessions; see Tables 2 and 3).
- Instructions will only be given when the student asks for some clarification.

- The test questions will be taken from the reliable and trustworthy files for test questions from the selected schools of the study. The test and session questions will be chosen with help of the teachers who work with students of the same age range selected for the current research. The test questions will be somewhat similar, but the structure will be different. These tests are:

  – Pre-test: applied before the beginning of the first session, it will contain 6 questions.
  – After every five sessions, the student will be given a test of 6 questions to determine the extent of development using SCV and PRV.
  – Post-test: given after completing all the sessions, it will contain 6 questions.

The total number of students will a minimum of 30 students.

Table 2: Control Group (PRV): 7 girls and 10 boys

Week	Sessions
1	1–5
2	6–10
3	11–15
4	16–20

Table 3: Intervention group (SCV): 7 girls and 10 boys

Weeks	Sessions
1	1–5
2	6–10
3	11–15
4	16–20

University of Reading

14. Parents'/Carers' Information Sheet

Research Project: Solving mathematical word problems using passively received visualisation (PRV) and self-constructed visualisation (SCV): The case of primary school students with attention deficit hyperactivity disorder (ADHD) in Kuwait.
Researcher Name: Mrs Fatemah Almuwaiziri
Research Supervisors: Dr Natthapoj Vincent Trakulphadetkrai; Dr Tim Williams

We would like to invite your child to take part in a research study about learning mathematical word problems.

What is the study?

The study is being conducted by the University of Reading as PhD research. The study aims to help students with ADHD access mathematical word problems by using passively received visualisation (PRV) and self-constructed visualisation (SCV). PRV is when children use given images of objects to help visualise word problems, whereas SCV is when children create their own images and drawings to visualise word problems. Children will use two different apps to assist them during the PRV and SCV phases.

The study is an intervention study using a group comparison experiment. The comparison group will use PRV, and the intervention group will use SCV. The students will be randomly allocated into either the PRV or SCV groups. The researcher hopes to use the findings to make recommendations regarding how we can best help learners make progress in mathematical learning and how we can best prepare ADHD students to understand mathematical word problems and develop their abilities in solving word problems.

Why has my child been chosen to take part?

Your child has been invited to take part in the project because his/her mathematics teacher and school have expressed an interest in being involved in our project. All ADHD learners who are taught mathematics by her/his primary school in Years 4 and 5 (ages 9 to 11) are being invited to take part.

Does my child have to take part?

It is entirely up to you whether your child participates. You may also withdraw your consent to participate at any time during the project, without any repercussions to you or your child, by contacting the project researcher, Mrs Fatemah Almuwaiziri (Tel: +44(0)7727001555, email: zs885101@live.reading.ac.uk).

What will happen if my child takes part?

With your agreement, participation would involve us administering a mathematical word problem task to ADHD learners in the Year 4 and 5 class taught by Mrs Fatemah Almuwaiziri; these learners will have daily one-to-one sessions for a maximum 30 minutes for 5 weeks. Your child will complete a brief (6 questions) word problems pre-test in mathematics and interview lasting 15 to 30 minutes before the first session of the project starts. All the activities of the project will be video recorded. After every five sessions, the student will be given a test of 6 questions to determine the extent of the development of SCV or PRV use. A post-test (6 questions) will be given after completing all the sessions, and an interview will be conducted, lasting 15 to 30 minutes. Finally, a month after completing the experiment, a delayed test (6 questions) will be administered to see if the students continue to use the intervention. The test questions will be taken from reliable sources of test questions from the selected schools of the study. The test questions will be chosen with help of teachers working with students of the same age range selected for the research. These test questions will be somewhat similar, but the structure will be different.

Two observations will be used. First, an observation sheet based on the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5) will be used for video recordings while carrying out the experiment (for 25 sessions). It will be used to observe changing ADHD behaviours in terms of inattention and hyperactivity/impulsivity while using PRV and SCV for word problems in mathematics lessons. Second, an open-ended observation will be conducted during the experimental sessions (25 sessions) in order to understand how the students deal with and apply SCV and PRV. This observation will rely on note-taking to determine the extent to which students solve the mathematical word problems by using PRV and SCV.

The sessions will be completed with the researcher, Mrs Fatemah Almuwaiziri, who is fully CRB checked. The entire research process will be similar for both the PRV and SCV groups. As we hope that we can set your child's learning of mathematics into context, we would also like your permission for their current school to share details of their attainment in mathematics and ADHD diagnosis report.

If you agree to your child's participation, we will seek further consent from the head teacher and the children themselves.

What are the risks and benefits of taking part?

The information you and your child give will remain confidential and will only be seen by the research team listed at the start of this letter. Neither you, your child, nor the school will be identifiable in any published report resulting from the study. Taking part will in no way influence the grades your child receives at school. Information about individuals will not be shared with the school.

Participants in similar studies have found it interesting to complete the tests and interviews that we will administer. We anticipate that the findings of the study will be useful for teachers in planning how they teach mathematical word problems. An electronic copy of the published findings of the study can be made available to you by contacting the project researcher.

What will happen to the data?

Any data collected will be held in strict confidence, and no real names will be used in this study or in any subsequent publications. The records of this study will be kept private. No identifiers linking you, your child, or the school to the study will be included in any sort of report that might be published. We will transcribe the recordings from the tests and anonymise them before analysing the results. Children will be assigned a number and will be referred to by that number on all audio recordings and in all interviews. Research records will be stored securely in a locked filing cabinet and on a password-protected computer, and only the research team will have access to the records. In line with the University of Reading's policy on the management of research data, anonymised data gathered in this research may be preserved and made publicly available for others to consult and re-use. The results of the study will be presented at national and international conferences and in written reports and articles.

Who has reviewed the study?

This project has been reviewed following the procedures of the University Research Ethics Committee and has been given a favourable ethical opinion for conduct. The University of Reading has the appropriate insurances in place. Full details are available on request.

What happens if I/my child change our mind?

You/your child can change your mind at any time without any repercussions. During the research, your child can stop completing the activities at any time. If you change your mind after data collection has ended, we will discard your/your child's data.

What happens if something goes wrong?

In the unlikely case of a concern or complaint, you can contact the researcher, Mrs Fatemah Almuwaiziri (Tel: +44(0)7727001555, email: zs885101@live.reading.ac.uk) or her supervisor, Dr Natthapoj Vincent Trakulphadetkrai (n.trakulphadetkrai@reading.ac.uk).

Where can I get more information?

If you would like more information, please contact the researcher, Mrs Fatemah Almuwaiziri.

We do hope that you will agree to your child's participation in the study and to your involvement in it. If you do, please complete the attached consent form and return it by email to: zs885101@live.reading.ac.uk.

Thank you for your time.

15. Parents'/Carers' Consent Form

Research Project: Solving mathematical word problems using passively received visualisation (PRV) and self-constructed visualisation (SCV): The case of primary school students with attention deficit hyperactivity disorder (ADHD) in Kuwait.

I have read the Information Sheet about the project and received a copy of it.

I understand what the purpose of the project is and what is required of my child and me. All my questions have been answered.

Name of child: ____

Name of primary school: _______________________________

Please tick as appropriate:

I consent to my child completing the mathematics task and interview ☐

I consent to the school giving the research team details of my child's grades in mathematics and ADHD diagnosis report ☐

I consent to my child completing the mathematical tasks and interview in school ☐

I consent to the video-recording of my child completing the mathematics tasks ☐

I consent to my child completing an interview ☐

To allow the researcher to contact you after data collection or in the case of publications, please provide the following details:

Name of parent/carer: ____

Parent/carer postal address:

____

____

Parent/carer telephone number (mobile preferred): ___________________________

Signed: _____________________________

Date: _________________________________

16. Head Teachers' Information Sheet

Research Project: Solving mathematical word problems using passively received visualisation (PRV) and self-constructed visualisation (SCV): The case of primary school students with attention deficit hyperactivity disorder (ADHD) in Kuwait.
Researcher Name: Mrs Fatemeh Almuwaiziri
Research Supervisors: Dr Natthapoj Vincent Trakulphadetkrai; Dr Tim Williams

Dear Head Teacher

I am writing to invite your school to take part in a research study about learning mathematical word problems.

What is the study?

A few weeks ago, I contacted you about a study I am conducting at the University of Reading as PhD research. The study aims to help students with ADHD access mathematical word problems by using passively received visualisation (PRV) and self-constructed visualisation (SCV). PRV is when children use given images of objects to help visualise word problems, whereas SCV is when children create their own images and drawings to visualise word problems. Children will use two different apps to assist them during the PRV and SCV phases.

The current study is an intervention study using a group comparison experiment. The comparison group will use PRV, and the intervention group will use SCV. The students will be randomly allocated into the PRV and SCV groups. I hope to use the findings from this study to make recommendations regarding how we can best help learners make progress in mathematical learning and how we can best prepare ADHD students to understand mathematical word problems and develop their abilities in solving word problems.

Why has this school been chosen to take part?

Following the pilot study, you expressed an interest in further involvement with the project. In addition, your school is being invited to take part in the project because it is a special school for students with learning abilities, including ADHD. As a former teacher in one of these schools, I observed how such schools face problems teaching mathematical word problems for students with ADHD.

Does the school have to take part?

It is entirely up to you whether you give permission for the school to participate. You may also withdraw your consent to participate at any time during the project, without any repercussions to you, by contacting me as the researcher (Tel: +44(0)7727001555, email: zs885101@live.reading.ac.uk).

What will happen if the school takes part?

With your agreement, participation would involve me administering mathematics word problem tasks to ADHD learners in the Year 4 and 5 (ages 9 to 11) class that I teach; these learners will have daily one-to-one sessions with me for a maximum of 30 minutes for 5 weeks. Your students will complete a brief (6 questions) word problems pre-test in mathematics and be interviewed for 15 to 30 minutes before the first session of the project. All project activities will be video recorded. After every five sessions, the student will be given a test of 6 questions to determine the extent of development in using SCV and PRV. A post-test of 6 questions will be given after completing all the sessions, and an interview will be conducted, lasting 15 to 30 minutes. Finally, a month after the experiment concludes, a delay test of 6 questions will be administered to see if the students continue using the intervention. The test questions will be taken from reliable sources of test questions from the selected schools of the study. The test questions will be chosen with the help of the teachers who work with students of the same age range selected for the current research. These tests questions will be somewhat similar, but the structure will be different.

Two observations will be used. First, an observation sheet based on the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5) will be used for video recordings while carrying out the experiment (for 25 sessions). It will be used to observe changing ADHD behaviours in terms of inattention and hyperactivity/impulsivity while using PRV and SCV for word problems in mathematics lessons. Second, an open-ended observation will be conducted during the experimental sessions (25 sessions) in order to understand how the students deal with and apply

SCV and PRV. This observation will rely on note-taking to determine the extent to which students solve the mathematical word problems by using PRV and SCV.

As the researcher, I will complete all sessions; I am fully CRB checked. The entire research process will be similar for both the PRV and SCV groups. To establish the students learning of mathematics in context, I would also like your permission for the school to share details of their attainment in mathematics and ADHD diagnosis report.

If you agree to the school's participation, I will seek further consent from parents/carers and the children themselves.

What are the risks and benefits of taking part?

The information given by participants in the study will remain confidential and will only be seen by the research team listed at the start of this letter. Neither you, the children, nor the school will be identifiable in any published report resulting from the study. Information about individuals will not be shared with the school. Participants in similar studies have found it interesting to take part. I anticipate that the findings of the study will be useful for teachers in planning how they teach mathematical word problems.

What will happen to the data?

Any data collected will be held in strict confidence, and no real names will be used in this study or in any subsequent publications. The records of this study will be kept private. No identifiers linking you, the children, or the school to the study will be included in any sort of report that might be published. Participants will be assigned a number and will be referred to by that number in all records. Research records will be stored securely in a locked filing cabinet and on a password-protected computer, and only the research team will have access to the records. In line with the University of Reading's policy on the management of research data, anonymised data gathered in this research may be preserved and made publicly available for others to consult and re-use. The results of the study will be presented at national and international conferences and in written reports and articles. I can send you electronic copies of these publications if you wish.

What happens if I change my mind?

You can change your mind at any time without any repercussions. If you change your mind after data collection has ended, I will discard the school's data.

What happens if something goes wrong?

In the unlikely case of a concern or complaint, you can contact me (Tel: +44(0)7727001555, email: zs885101@live.reading.ac.uk) or my supervisor, Dr. Natthapoj Vincent Trakulphadetkrai (n.trakulphadetkrai@reading.ac.uk).

Where can I get more information?

If you would like more information, please contact me.

This project has been reviewed following the procedures of the University Research Ethics Committee and has been given a favourable ethical opinion for conduct. The University of Reading has the appropriate insurances in place. Full details are available on request.

I do hope that you will agree to your school's participation in the study. If you do, please complete the attached consent form and return it by email to me： zs885101@live.reading.ac.uk.

Thank you for your time.

Yours sincerely,

XXXX

17. Head Teachers' Consent Form

I have read the Information Sheet about the project and received a copy of it.

I understand what the purpose of the project is and what is required of me. All my questions have been answered.

Name of Head Teacher: ____

Name of primary school: ____

Please tick as appropriate:

I consent to the involvement of my school in the project as outlined in the Information Sheet ☐

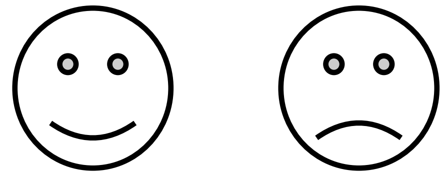
Signed: ______________________________

Date: __________________________________

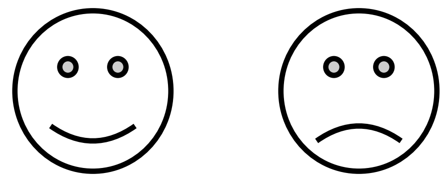
18. Children's Consent Form

Note: This form is for young children. The statements are read, and the child colours the face to indicate consent or not.

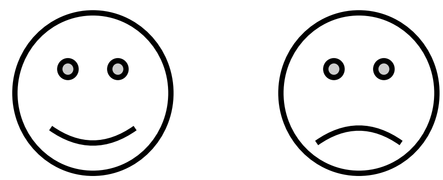
Miss Fatemah has told me about the reason for the maths lessons.



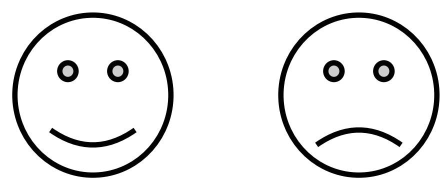
Miss Fatemah has answered the questions I have had about the maths lessons.



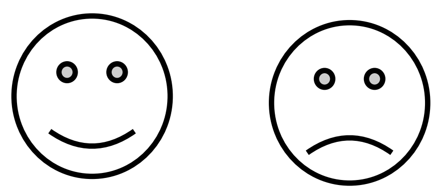
I know that I will be telling Miss Fatemah how I feel about maths and answering questions.



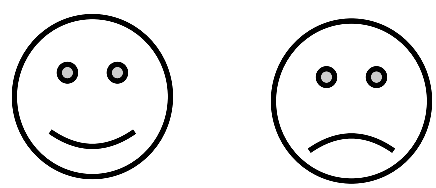
I am happy for Miss Fatemah to use my work for her project.



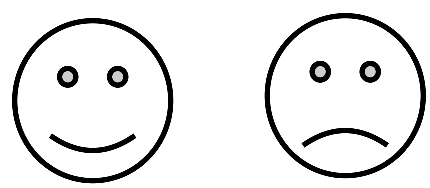
I understand what the study is about.



I understand that I don't have to take part and can drop out of the study at any time.



I agree to take part in this study.



My Name: …………………………………………………………………..
My Age…………………..

Date: ……………………………………..

19. Children's Information Sheet

What happens next?

Your parents have been sent a letter asking for their permission for you to take part in this project.

We will check with you before we do the tasks that you are happy to help us with our project.

If you have any questions, please speak to your class teacher or Mrs Fatemeh Almuwaiziri by email: zs885101@live.reading.ac.uk

Or you can contact

my supervisor Dr. Natthapoj Vincent Trakulphadetkrai by email: n.trakulphadetkrai@reading.ac.uk.

The researcher:
Mrs Fatemeh Almuwaiziri

This project has been reviewed following the procedures of the University of Reading Research Ethics Committee and has been given a favourable ethical opinion for conduct.

University of Reading

Institute of Education
London Road Campus
RG1 5EX

Research Project: Solving mathematical word problems using passively received visualisation (PRV) and self-constructed visualisation (SCV): The case of Attention Deficit Hyperactivity Disorder (ADHD) primary school students in Kuwait.

Information Sheet

We are doing a project to help students with ADHD to access mathematical word problems by using visualizations (Apps). We will try to examine and explore how using visual aids can improve mathematics learning for students with ADHD.

Why have I been invited to take part?

You have been invited to take part because your teacher and parents are interested in this project. You will be randomly allocated into either the PRV or the SCV group.

What will I have to do if I agree to take part?

We will give you daily one-to-one sessions for five weeks, which are in total 25 sessions, by using apps to learn mathematical word problems. And these sessions will be video recorded.

We will also ask you to answer interview questions, about how you feel about learning mathematical word problems, when you are using apps.

Will anyone know about my answers?

Only the people working on the project will know about your answers. We will not tell your school how you answered, or your parents.

Will it help me if I take part?

We think you will find it interesting and fun to do the mathematical word problems by using apps. Your answers will help your teachers to know the best ways to teach mathematics word problems.

Do I have to take part?

No, not at all. Also, you can stop helping us with our project at any time, without giving a reason. Just ask your teacher or your parents to tell us if you want to stop.

20. Children's Post-test Interview Questions

These semi-structured interviews questions will be asked with each participant after the experiment is completed to understand if the students successfully used the research tools. Furthermore, for the pilot study, the main objective is to understand if the participants can respond to these interview questions appropriately and if their answers serve the objective required of the main study. For the main study, these interviews will try to address students' perceptions in order to understand how they learn mathematical word problems by using passively received visualisation (PRV) and self-constructed visualisation (SCV). PRV is when children use given images of objects to help visualise word problems, whereas SCV is when children create their own images and drawings to visualise word problems. Children will use two different apps to assist them during the PRV and SCV phases. These interviews will take place after the post-test and will take between 15 and 30 minutes; they will be video recorded due to the nature of questions 2 and 3.

Table 1

Interview Questions and Theories

Questions	Theories
Did you like using SCV/PRV to solve mathematical word problems? If not, why not?	
In the past 5 sessions with me, you used SCV/PRV. If I give you this word problem (give student a paper with a written word problem on it), what is first thing that comes to your mind to solve this problem?	Representation (Bruner, 1966), conceptual understanding (Kilpatrick, Swafford, & Findell, 2001)
For the same word problem (written on the paper), can you explain how you would solve it?	Intelligent learning or relational understanding (Skemp, 1989), procedure fluency (Kilpatrick et al., 2001)
When you did the test with me, how did you solve the exam problems?	Intelligent learning or relational understanding (Skemp, 1989), procedure fluency (Kilpatrick et al., 2001)
Did you refer to the SCV/PRV in your mind while doing the test with me? If yes, how? What happened exactly?	Representation (Bruner, 1966)

While doing the test with me, which one did you refer to most SCV or PRV? Why?	Conceptual understanding (Kilpatrick et al., 2001)
How did using SCV/PRV in the last 20 sessions help you solve the word problem test?	Representation (Bruner, 1966)
Would you ask your teacher to use SCV/PRV in class?	
If you have the freedom not use the SCV/PRV, would you do so? Or do you prefer to use them?	

21. Ethical Approval after Adding Teachers' Interviews and Surveys

University of Reading
Institute of Education
Ethical Approval Form A (version May 2015)

Tick one:

Staff project: ____ (PhD) ___ EdD ___

Name of applicant (s): Fatemah Almuwaiziri

Title of project: Solving mathematical word problems using passively visualisation (PRV) and self-constructed visualisation (SCV): The case of Attention Deficit Hyperactivity Disorder (ADHD) primary school students in Kuwait.

Name of supervisor (for student projects): Natthapoj Vincent Trakulphadetkrai

Please complete the form below including relevant sections overleaf.

	YES	NO	
Have you prepared an Information Sheet for participants and/or their parents/carers that:			
a) explains the purpose(s) of the project	X		
b) explains how they have been selected as potential participants	X		
c) gives a full, fair and clear account of what will be asked of them and how the information that they provide will be used	X		
d) makes clear that participation in the project is voluntary	X		
e) explains the arrangements to allow participants to withdraw at any stage if they wish	X		
f) explains the arrangements to ensure the confidentiality of any material collected during the project, including secure arrangements for its storage, retention and disposal	X		
g) explains the arrangements for publishing the research results and, if confidentiality might be affected, for obtaining written consent for this	X		
h) explains the arrangements for providing participants with the research results if they wish to have them	X		
i) gives the name and designation of the member of staff with responsibility for the project together with contact details, including email . If any of the project investigators are students at the IoE, then this information must be included and their name provided	X		
k) explains, where applicable, the arrangements for expenses and other payments to be made to the participants		X	
j) includes a standard statement indicating the process of ethical review at the University undergone by the project, as follows: 'This project has been reviewed following the procedures of the University Research Ethics Committee and has been given a favourable ethical opinion for conduct'.	X		
k)includes a standard statement regarding insurance: "The University has the appropriate insurances in place. Full details are available on request".	X		
Please answer the following questions			
1) Will you provide participants involved in your research with all the information necessary to ensure that they are fully informed and not in any way deceived or misled as to the purpose(s) and nature of the research? (Please use the subheadings used in the example information sheets on blackboard to ensure this).	X		
2) Will you seek written or other formal consent from all participants, if they are able to provide it, in addition to (1)?	X		
3) Is there any risk that participants may experience physical or psychological distress in taking part in your research?		X	
4) Have you taken the online training modules in data protection and information security (which can be found here: http://www.reading.ac.uk/internal/imps/Staffpages/imps-training.aspx)?	X		
5) Have you read the Health and Safety booklet (available on Blackboard) and completed a Risk Assessment Form to be included with this ethics application?	X		
6) Does your research comply with the University's Code of Good Practice in Research?	X		
	YES	NO	N.A.
7) If your research is taking place in a school, have you prepared an information sheet and consent form to gain the permission in writing of the head teacher or other relevant supervisory professional?	X		

8) Has the data collector obtained satisfactory DBS clearance?	X		
9) If your research involves working with children under the age of 16 (or those whose special educational needs mean they are unable to give informed consent), have you prepared an information sheet and consent form for parents/carers to seek permission in writing, or to give parents/carers the opportunity to decline consent?	X		
10) If your research involves processing sensitive personal data[1], or if it involves audio/video recordings, have you obtained the explicit consent of participants/parents?	X		
11) If you are using a data processor to subcontract any part of your research, have you got a written contract with that contractor which (a) specifies that the contractor is required to act only on your instructions, and (b) provides for appropriate technical and organisational security measures to protect the data?			X
12a) Does your research involve data collection outside the UK?	X		
12b) If the answer to question 12a is "yes", does your research comply with the legal and ethical requirements for doing research in that country?	X		
13a) Does your research involve collecting data in a language other than English?	X		
13b) If the answer to question 13a is "yes", please confirm that information sheets, consent forms, and research instruments, where appropriate, have been directly translated from the English versions submitted with this application.	X		
14a. Does the proposed research involve children under the age of 5?		X	
14b. If the answer to question 14a is "yes": My Head of School (or authorised Head of Department) has given details of the proposed research to the University's insurance officer, and the research will not proceed until I have confirmation that insurance cover is in place.			X
If you have answered YES to Question 3, please complete Section B below			

Please complete **either** Section A **or** Section B and provide the details required in support of your application. Sign the form (Section C) then submit it with all relevant attachments (e.g. information sheets, consent forms, tests, questionnaires, interview schedules) to the Institute's Ethics Committee for consideration. Any missing information will result in the form being returned to you.

A: My research goes beyond the 'accepted custom and practice of teaching' but I consider that this project has **no** significant ethical implications. (Please tick the box.)	X

Please state the total number of participants that will be involved in the project and give a breakdown of how many there are in each category e.g. teachers, parents, pupils etc.

approximately a minimum of 20 males and 15 females ADHD will be invited to participate in this study in Kuwaiti primary schools.

Give a brief description of the aims and the methods (participants, instruments and procedures) of the project in up to 200 words noting:

1. title of project:
   Research Project (Title): Solving mathematical word problems using passively visualisation (PRV) and self-constructed visualisation (SCV): The case of Attention Deficit Hyperactivity Disorder (ADHD) primary school students in Kuwait.

2. purpose of project and its academic rationale:
   The study aims to help students with ADHD accessing mathematical word problems by using: passively received visualisation (PRV) and self-constructed visualisation (SCV). PRV is when children use given images of objects to help visualise word problems, whereas SCV is when children create their own images and drawings to visualise word problems. Children will use two different apps to assist them during the PRV and SCV phases. It hopes to make recommendations regarding how we can best help learners to make progress in mathematical learning, and how we can best prepare ADHD students understanding mathematical word problems and develop their abilities in solving word problems.

3. brief description of methods and measurements:
   To answer the first research question (To what extent do passively received visualisation (PRV) and self-constructed visualisation (SCV) help ADHD students solve mathematics word problems?) two methods will be used. First, a single-case experimental design will be used by applying multiple base line design. The current

[1] Sensitive personal data consists of information relating to the racial or ethnic origin of a data subject, their political opinions, religious beliefs, trade union membership, sexual life, physical or mental health or condition, or criminal offences or record.

study is designed to have a daily one-to-one session last for maximum 30 minutes for 25 sessions in total. In each session the student will solve 6-word problems. After each 5 sessions, the student will be tested. The test will include 6-word problems which will be solve in 15 minutes. For the current study, the students will be randomly allocated in a design that involves two groups of students: students using (PRV) the control group and students using (SCV) the intervention group. Furthermore, pre-test will be applied before the beginning of the first session to underline the student's mathematical level. The students will be allocated in to the groups (SCV and PRV) depend on the pre-test score (high, mid and low), where each group will contain students with (high, mid and low) score. The students in both group (control and intervention) will use both apps for SCV and PRV for the same length of time (5 weeks equivalent to 25 sessions). This will demonstrate the effect of using SCV to solve mathematical word problems for each ADHD student. The intervention group will have 15 min introductory session before starting the intervention sessions. The main objectives of the introductory session are to make sure that the students understand what creating or constructing drawing means and to solve any confusion regarding of using the instrument. In the end of the experiment (after the last session) a post- test will be applied to evaluate student's development by using PRV and SCV. The tests questions will be taken from the reliable tests files questions from the selected schools of the study. The choice of the test questions will be done with help of the teachers of the same age range selected for the current research. These tests questions will be somewhat similar, but the structure will be different.

Second, a qualitative observation will be conducted during the experimental sessions (5 sessions per week for 5 weeks) in order to understand how deal and Apply SCV and PRV. The qualitative observation will be applied through an open observation by notes taking to comprehend to some extend how the students solved the mathematics word problem by using PRV and SCV. For example, for PRV sessions the observation notes was about if the students understand the given pictures, did they look using the given picture, the kind of the questions they did ask during the sessions, did they just guess the answers or they really solve it and did they solve the problem correctly. In SCV sessions the observations note mostly about what kind of questions did they asked, how they started solving the problems, what the first step they follow, what type of drawing they great, the quality of drawing, what comments they made or asked and did they solve the problems correctly.

To answer the second research problem (To what extent do PRV and SCV help ADHD students remain focused while solving mathematics word problems?), structured observation will be used (quantitative observation) by following scheduled categories that shape the observation in counting the events. The observation is established to observe ADHD changing behaviour in (Inattentions) and (Hyperactive and Impulsivity) while using PRV and SCV through 25 sessions for mathematic word problems. Observing inattentions is divided in to 7 categories and hyperactive and impulsivity is divided to 6 categories. The observation sheet is developed from DSM-5 (Diagnostic and statistical manual of mental disorders) for 25 sessions for each child. Where each child will have daily one-to-one session for maximum 30 minutes. The observations will be collected from a video recorded for each student during the experiment. These observations will indicate the occurrence of the ADHD behaviour. If the behaviour accrue I will put (1), if not accrue I will put (0).

Students interviews will be used to answer the third research questions (What are ADHD children's perceptions on using PRV and SCV to solve mathematics word problems?). Using semi-structured interviews will provide more information about how students with ADHD learn through applying PRV and SCV by using reflections of interviewee views (students). Each child will be interviewed separately twist. First, for at least 13 to 15 minutes before the first session started. This to understand their general abilities to solve mathematic word problems, and if they prefer to use technology (e.g. apps) to solve mathematical problems. The second interviews will take place after the post-test. The interviews questions can take time between 17 to 20 minutes, each question in both interviews might take time between 1 to 3 minutes depend on the nature of the question and the speed of responding. The interviews will be held in safe environment (the schools) at school time. These interviews will be video recorded and transcribed. The transcript will be translated from Arabic to English by using translator.

To answer the fourth research question (What are the teacher's perceptions of the influences of using SCV and PRV on solving mathematical word problems and the behaviour for students with ADHD?), a structured questionnaire and a semi-structured interview will be used. The questionnaire is divided into two parts. The first part will discuss the mathematical abilities in general of the selected ADHD students before and after applying the experiment. The second part will discuss ADHD behaviours for the selected ADHD students before and after applying the experiment. The questionnaire will take between 5 and 7 minutes. The scale of this questionnaire is between 1 to 5, where 1 is totally disagree, and 5 is totally agree. The primary goal for this questionnaire is to support the data and results from the experiment sessions which will last for four weeks. It will reflect the teachers' perceptions of the selected students from their classes who were part of the experiment. The semi-structured interview questions will be applied to the participants after the experiment process is finished. These interviews will try to address the teachers perceptions in order to understand if the students learned how to tackle mathematical word problems by using passively received visualisation (PRV) and self-constructed visualisation (SCV). PRV is when children use given images of objects to help visualise word problems, whereas SCV is when children create their own images and drawings to visualise word problems. Thus, These interviews will help the researcher to understand if the students successfully used the research tools during the four weeks of the experiment in both groups (PRV and SCV). Each interview will take between 15 and 20 minutes.

4. participants: recruitment methods, number, age, gender, exclusion/inclusion criteria:
   approximately a maximum of 20 males and 15 females age 9 to 11 years old will be invited to participate in this study. The students will be randomly distributed in to the intervention group (SCV) and control grope (PRV) depend on the pre-test score (high, mid, and low), where each group will have students with (high, mid, and low) score.

5. consent and participant information arrangements, debriefing (attach forms where necessary):
   As this study will be applied in schools, three types of consent form are needed. First, I need a consent form for the head teacher of each school with information sheet to clarify the natural of study will be held in their schools. Second, I need to develop a consent and information sheet for the parents. This to give a clear idea for the parents about what their children will be involve in, why their children have been chosen, and what are their right. Finally, the child has the right to understand what they are involve in, and their rights as apart of the project. Thus, I developed and information sheet and consents form for the students. As Ministry of Education in Kuwait asked to send an email explaining the details of the study, thus I have created an email with all the details required.

6. a clear and concise statement of the ethical considerations raised by the project and how you intend to deal with then:
   This project is promising to respect the information and the participants by being honest and avoid any possible harm to both researcher and participants. Additionally, this project will ensure that any undertaken research is within the law by following the university of Reading code of good practice in research (UKRIO Code). To conduct the study, I need to get permission to collect the data and working in the field. The permission to conduct this study will be obtained from the Ethics Committee of the university of Reading and the Ministry of Education in Kuwait. This research will be conducted with children, thus the research ethics will be all circulated around ensuring the safety and avoiding harm for the children. Moreover, consent forms are critical point of research ethics, as this research participants are children in schools three consent forms should be established (for school's head teaches, for parents, for children) with written guarantee of confidentiality and anonymity. My supervisors and I are the only persons who will access the recorded data from the experiment, observations and interviews. These recorded will be deleted once the research finished. To ensure participants comfortability and safety, they have the right to withdraw at any stage of the research. In addition, all research process will be conducted in school environment with knowledge of locating the time.

7. estimated start date and duration of project:
   the estimated starting date of the project will be in beginning of March until the end of April.

B: I consider that this project **may** have ethical implications that should be brought before the Institute's Ethics Committee.	

Please state the total number of participants that will be involved in the project and give a breakdown of how many there are in each category e.g. teachers, parents, pupils etc.

Give a brief description of the aims and the methods (participants, instruments and procedures) of the project in up to 200 words.

1. title of project
2. purpose of project and its academic rationale
3. brief description of methods and measurements
4. participants: recruitment methods, number, age, gender, exclusion/inclusion criteria
5. consent and participant information arrangements, debriefing (attach forms where necessary)
6. a clear and concise statement of the ethical considerations raised by the project and how you intend to deal with then.
7. estimated start date and duration of project

C: SIGNATURE OF APPLICANT:

Note: a signature is required. Typed names are not acceptable.

I have declared all relevant information regarding my proposed project and confirm that ethical good practice will be followed within the project.

Signed: …………*Fatma*……… Print Name…Fatemah Almuwaiziri…………………… Date 20-07-2018…………

STATEMENT OF ETHICAL APPROVAL FOR PROPOSALS SUBMITTED TO THE INSTITUTE ETHICS COMMITTEE

This project has been considered using agreed Institute procedures and is now approved.

Signed: …[redacted] Print Name: Dr Karen Jones Date: 21 December 2018
(IoE Research Ethics Committee representative)*

* A decision to allow a project to proceed is not an expert assessment of its content or of the possible risks involved in the investigation, nor does it detract in any way from the ultimate responsibility which students/investigators must themselves have for these matters. Approval is granted on the basis of the information declared by the applicant.

22. Teachers' Information Sheet

Research Project:

Solving mathematical word problems using passively received visualisation (PRV) and self-constructed visualisation (SCV): The case of primary school students with attention deficit hyperactivity disorder (ADHD) in Kuwait.

Researcher's Name:
Mrs Fatemeh Almuwaiziri
Research Supervisors:
Dr Natthapoj Vincent Trakulphadetkrai; Dr Tim Williams

Dear Teacher

I am writing to invite you to take part in a research study about learning mathematical word problems.

What is the study?

The study I am conducting at the University of Reading as PhD research that aims to help students with ADHD access mathematical word problems by using passively received visualisation (PRV) and self-constructed visualisation (SCV). PRV is when children use given images of objects to help visualise word problems, whereas SCV is when children create their own images and drawings to visualise word problems. Children will use two different apps to assist them during the PRV and SCV phases.

The study is an intervention study using a group comparison experiment. The comparison group will use PRV, and the intervention group will use SCV. The students will be randomly allocated into the PRV and SCV groups. I hope to use the findings to make recommendations regarding how we can best help learners make progress in mathematical learning and how we can best prepare ADHD students to understand mathematical word problems and develop their abilities to solve word problems.

Why you have been chosen to take part

Your school is being invited to take part in the project because it is a special school for students with learning disabilities, including ADHD, and because I previously taught in a similar school, where I observed the problems the school faced teaching mathematical word problems to students with ADHD. I have been working with one or more students in your class diagnosed with ADHD. Therefore, I would like to record your perceptions of the students involved in one of the study groups (PRV or SCV group) before and after the study through a questionnaire and then possibly an interview.

Do I have to take part?

It is entirely up to you whether you want to participate or not. You may also withdraw your consent to participate at any time during the project, without any repercussions to you, by contacting me (Tel: +44(0)7727001555, email: zs885101@live.reading.ac.uk).

What will happen if I take part?

With your agreement, you will be invited to complete a questionnaire which will take between 5 and 7 minutes. In addition, after you finish the questionnaire, if you agree, you will be invited to take part in an interview which will take 15 to 20 minutes. All the above will be conducted in order to support the study data and understand the results in more depth.

What are the risks and benefits of taking part?

The information given by participants in the study will remain confidential and will only be seen by the research team listed at the start of this letter. Neither you, the children, nor the school will be identifiable in any published report resulting from the study. Information about individuals will not be shared with the school. Participants in similar studies have found it interesting to take part. I anticipate that the findings of the study will be useful for teachers in planning how they teach mathematical word problems.

What will happen to the data?

Any data collected will be held in strict confidence, and no real names will be used in this study or in any subsequent publications. The records of this study will be kept private. No identifiers linking you, the children, or the school to the study will be included in any sort of report that might be published. Participants will be assigned a number and will be referred to by that number in all records. Research records will be stored securely in a locked filing cabinet and on a password-protected computer, and only the research team will have access to the records. In line with the

University of Reading's policy on the management of research data, anonymised data gathered in this research may be preserved and made publicly available for others to consult and re-use. The results of the study will be presented at national and international conferences and in written reports and articles. I can send you electronic copies of these publications if you wish.

What happens if I change my mind?

You can change your mind at any time without any repercussions. If you change your mind after data collection has ended, we will discard your data.

What happens if something goes wrong?

In the unlikely case of a concern or complaint, you can contact me (+44(0)7727001555 or zs885101@live.reading.ac.uk) or my supervisor, Dr. Natthapoj Vincent Trakulphadetkrai (n.trakulphadetkrai@reading.ac.uk).

Where can I get more information?

If you would like more information, please contact me.

This project has been reviewed following the procedures of the University Research Ethics Committee and has been given a favourable ethical opinion for conduct. The University of Reading has the appropriate insurances in place. Full details are available on request.

I do hope that you will agree to participate in the study. If you do, please complete the attached consent form and return it to me directly or by email (zs885101@live.reading.ac.uk).

Thank you for your time.

Yours sincerely,

Fatemah Almuwaiziri

23. Teachers' Consent Form

I have read the Information Sheet about the project and received a copy of it.

I understand what the purpose of the project is and what is required of me. All my questions have been answered.

Name of teacher: ____

Name of primary school: ____

Please tick as appropriate:

I agree to participate in the project as outlined in the Information Sheet ☐

Signed: ______________________________

Date: __________________________________

24. Head Teachers' Information Sheet

Research Project:
Solving mathematical word problems using passively received visualisation (PRV) and self-constructed visualisation (SCV): The case of primary school students with attention deficit hyperactivity disorder (ADHD) in Kuwait.
Researcher Name:
Mrs Fatemeh Almuwaiziri
Research Supervisors:
Dr Natthapoj Vincent Trakulphadetkrai; Dr Tim Williams

Dear Head Teacher

I am writing to invite your school to take part in a research study about learning mathematical word problems.

What is the study?

A few weeks ago, I contacted you about a study I am conducting at the University of Reading as PhD research. The study aims to help students with ADHD access mathematical word problems by using passively received visualisation (PRV) and self-constructed visualisation (SCV). PRV is when children use given images of objects to help visualise word problems, whereas SCV is when children create their own images and drawings to visualise word problems. Children will use two different apps to assist them during the PRV and SCV phases.

The study is an intervention study using a group comparison experiment. The comparison group will use PRV, and the intervention group will use SCV. The students will be randomly allocated into the PRV and SCV groups. I hope to use the findings to make recommendations regarding how we can best help learners make progress in mathematical learning and how we can best prepare ADHD students to understand mathematical word problems and develop their abilities to solve word problems.

Why has this school been chosen to take part?

Following the pilot study, you kindly expressed an interest in further involvement with the project. The reason your school was chosen to take part in the project is because it is a special school for students with learning disabilities, including ADHD. In additionally, I previously taught in a special school for students with learning disabilities, where I observed how the teachers faced problems teaching mathematical word problems to students with ADHD. This information was confirmed by the pilot study conducted in your school.

Does the school have to take part?

It is entirely up to you whether you give permission for the school to participate. You may also withdraw your consent to participate at any time during the project, without any repercussions to you, by contacting me (Tel: +44(0)7727001555, email: zs885101@live.reading.ac.uk).

What will happen if the school takes part?

With your agreement, participation would involve me administering a mathematical word problem task to ADHD learners in the Year 4 and 5 (ages 9 to 11) class that I teach. These learners will have daily one-to-one sessions for a maximum 30 minutes for 5 weeks. Your students will complete a brief (6 questions) word problem pre-test in mathematics and be interviewed for 15 to 30 minutes before the first session of the project. All project activities will be video recorded. After every five sessions, the students will be given a test of 6 questions to determine the extent of their development using SCV and PRV. A post-test of 6 questions will be given after completing all the sessions, along with an interview lasting 15 to 30 minutes. Finally, a month after the experiment concludes, a delay test of 6 questions will be administered to see if the students continue using the intervention. The test questions will be taken from reliable sources from the selected schools of the study. The test questions will be chosen with the help of teachers working with students of the same age range selected for the current research. These test questions will be somewhat similar, but the structure will be different.

Furthermore, two observations will be used. First, an observation sheet based on the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5) will be used for video recordings while carrying out the experiment (for 25 sessions). It will be used to observe changing ADHD behaviours in terms of inattention and hyperactivity/impulsivity while using PRV and SCV for word problems in mathematics lessons. Second, an open-ended observation will be conducted during the experimental sessions (25 sessions) in order to understand how the students deal with and apply SCV and PRV. This observation will rely on note-taking to determine the extent to which students solve the mathematical word problems by using PRV and SCV.

After finishing the study sessions with the students, the post-test questionnaires will be distributed to the class teachers of the participating students, in order to support the study results. After the teachers complete the questionnaires (which will take between 5 and 7 minutes), the teachers who report the most and/or fewest advantages of the intervention will be invited to participate in interviews lasting 15 to 20 minutes.

I will conduct all sessions, and I have been checked with a full criminal report history. All research processes will be similar for both PRV and SCV groups. I hope to be able to establish students' learning of mathematics in context, so I also would like your permission for the school to share details of their mathematics attainment and ADHD diagnosis report.

If you agree to the school's participation, I will seek further consent from parents/carers and the children themselves.

What are the risks and benefits of taking part?

The information given by participants in the study will remain confidential and will only be seen by the research team listed at the start of this letter. Neither you, the children, nor the school will be identifiable in any published report resulting from the study. Information about individuals will not be shared with the school. Participants in similar studies have found it interesting to take part. I anticipate that the findings of the study will be useful for teachers in planning how they teach mathematical word problems.

What will happen to the data?

Any data collected will be held in strict confidence, and no real names will be used in this study or in any subsequent publications. The records of this study will be kept private. No identifiers linking you, the children, or the school to the study will be included in any sort of report that might be published. Participants will be assigned a number and will be referred to by that number in all records. Research records will be stored securely in a locked filing cabinet and on a password-protected computer, and only the research team will have access to the records. In line with the University of Reading's policy on the management of research data, anonymised data gathered in this research may be preserved and made publicly available for others to consult and re-use. The results of the study will be presented at national and international conferences and in written reports and articles. I can send you electronic copies of these publications if you wish.

What happens if I change my mind?

You can change your mind at any time without any repercussions. If you change your mind after data collection has ended, we will discard the school's data.

What happens if something goes wrong?

In the unlikely case of a concern or complaint, you can contact me (+44(0)7727001555 or zs885101@live.reading.ac.uk) or my supervisor, Dr. Natthapoj Vincent Trakulphadetkrai (n.trakulphadetkrai@reading.ac.uk).

Where can I get more information?

If you would like more information, please contact me.

This project has been reviewed following the procedures of the University Research Ethics Committee and has been given a favourable ethical opinion for conduct. The University of Reading has the appropriate insurances in place. Full details are available on request.

I do hope that you will agree to your school's participation in the study. If you do, please complete the attached consent form and return it to me directly or by email (zs885101@live.reading.ac.uk).

Thank you for your time.

Yours sincerely,

Fatemah Almuwaiziri

25. Head Teachers' Consent Form

I have read the Information Sheet about the project and received a copy of it.

I understand what the purpose of the project is and what is required of me. All my questions have been answered.

Name of Head Teacher: ____

Name of primary school: ____

Please tick as appropriate:

I agree to the involvement of my school in the project as outlined in the Information Sheet ☐

Signed: ______________________________

Date: __________________________________

26. Teachers' Interview Questions

First name of teacher:………………. Class No:………
Name of student:…………..

Semi-structured interview questions will be asked of the participants after the study process is finished. These interviews will try to address the teachers' perceptions in order to understand if the students learned to solve mathematical word problems by using passively received visualisation (PRV) and self-constructed visualisation (SCV). PRV is when children use given images of objects to help visualise word problems, whereas SCV is when children create their own images and drawings to visualise word problems. Thus, these interviews will help the researcher understand if the students successfully used the research tools during the four weeks of the experiment in both groups (PRV and SCV). Each interview will take between 15 and 20 minutes and will be undertaken with the teachers who reported the most and fewest advantages of the intervention.

Table 1

Teachers' Interview Questions

Questions	Focus of the question
Tell me about the student's ADHD behaviour in the classroom.	ADHD behaviour
What strategies have you used to deal with the student's ADHD behaviour?	ADHD behaviour
Tell me about the student's mathematical abilities in general.	Mathematical performance
Have you noticed if the student tried to use any type of drawing strategies to solve mathematical problems, especially word problems?	-Project out the thinking -Ability to present their thinking
Does the student's ADHD behaviour affect his/her mathematical ability, especially word problems? How?	The link between ADHD and mathematical abilities
The student was part of the research project for one month. Did it affect the ADHD behaviour? How?	Measuring the experiment tools' ability to change ADHD behaviour
To what extent can the student control his/her ADHD behaviour now?	Measuring the experiment tools' ability to change ADHD behaviour

One month after the experiment, does the student show any development in mathematics in general? If yes, how?	Measuring the experiment tools' ability to develop ADHD mathematical abilities
Have you noticed that the student started using drawing strategies to solve mathematical problems, especially word problems?	-Measuring the experiment tools' ability to develop ADHD mathematical abilities -The effect of SCV and PRV in solving mathematics in general and mathematical word problems
Do you think this strategy (SCV or PRV) is useful for ADHD students to solve mathematical word problems?	Measuring influences of the SCV or PRV on mathematical ability
Do you think this strategy (PRV or SCV) is useful for ADHD students to control their ADHD behaviours?	Measuring influences of the SCV or PRV on ADHD behaviour
Do you think you will apply this strategy (PRV or SCV) in your class? Why or why not?	The possibility of the teacher using SCV or PRV

27. Class Teachers' Questionnaire

First name of teacher:………………. Class No:………
Name of student:…………..

This questionnaire is one of the study tools for PhD research conducted at the University of Reading. The aim is to help students with ADHD access mathematical word problems by using passively received visualisation (PRV) and self-constructed visualisation (SCV). PRV is when children use given images of objects to help visualise word problems, whereas SCV is when children create their own images and drawings to visualise word problems. The children will be given two different ways to assist them during the PRV and SCV phases. The study hopes to make recommendations to help learners progress in their mathematical learning as well as prepare ADHD students to understand mathematical word problems and develop their abilities to solve word problems.

This questionnaire is divided into two parts. The first part discusses the mathematical abilities in general of the selected students before and after applying the study. The second part discusses ADHD behaviours in the selected students before and after applying the study. The questionnaire will take between 5 and 7 minutes. The scale of this questionnaire ranges from 1 to 5, where 1 is *Totally disagree*, 2 is *To some extent I disagree*, 3 is *I am not sure*, 4 is *To some extent I agree*, and 5 is *Totally agree*. The primary goal of this questionnaire is to support the data and the results from the study sessions, which will last for four weeks. It will reflect the teachers' perceptions of the participating students in their classes.

Part 1: Student's Mathematical Abilities

Indicate the student's mathematical abilities **before the study**. Tick (√) your answer, where 1 is *Totally disagree*, 2 is *To some extent I disagree*, 3 is *I am not sure*, 4 is *To some extent I agree*, and 5 is *Totally agree*.

Questions	1 Totally disagree	2 To some extent I disagree	3 I am not sure	4 To some extent I agree	5 Totally agree
The student cannot identify the type of mathematical operation (i.e. division or multiplication) in most word problems.					
The student is able to provide a solution for most mathematical word problems.					
The student did not use any drawing strategies to find the solutions.					

Indicate the student's mathematical abilities **after the study**. Tick (√) your answer, where 1 is *Totally disagree*, 2 is *To some extent I disagree*, 3 is *I am not sure*, 4 is *To some extent I agree*, and 5 is *Totally agree*.

Questions	1 Totally disagree	2 To some extent I disagree	3 I am not sure	4 To some extent I agree	5 Totally agree
I noticed an improvement in the student's mathematical performance in general.					
The student can identify the type of operation (i.e. division or multiplication) in most word problems.					
The student is able to provide a solution for most mathematical word problems.					
The student is using drawing strategies to find the solutions.					

Part 2: Student's ADHD Behaviour

Indicate the student's ADHD behaviour **before the study**. Tick (√) your answer, where 1 is *Totally disagree*, 2 is *To some extent I disagree*, 3 is *I am not sure*, 4 is *To some extent I agree*, and 5 is *Totally agree*.

Questions	1 Totally disagree	2 To some extent I disagree	3 I am not sure	4 To some extent I agree	5 Totally agree
Inattention					
The student is missing details.					
The student's work is inaccurate to some extent.					
The student is facing difficulties remaining focused on tasks.					
The student's mind seems elsewhere.					
The student is easily distracted.					
The student has difficulties organising the task, such as deciding what to do, what to draw, and how to organise the drawing and ideas.					
The student avoids engagement in tasks.					
The student forgets daily activities.					
Hyperactivity and Impulsivity					
The student taps his/her hands or feet.					
The student moves in his/her seat.					
The student often leaves his/her seat or does not remain seated.					
The student runs or climbs in inappropriate situations.					
The student finds it uncomfortable to be still for an extended time.					
The student talks excessively.					

Indicate the student's ADHD behaviour **<u>after the study</u>**. Tick (√) your answer, where 1 is *Totally disagree*, 2 is *To some extent I disagree*, 3 is *I am not sure*, 4 is *To some extent I agree*, and 5 is *Totally agree*.

Questions	1 Totally disagree	2 To some extent I disagree	3 I am not sure	4 To some extent I agree	5 Totally agree
Inattention					
The student is missing details.					
The student's work is inaccurate to some extent.					
The student is facing difficulties remaining focused on tasks.					
The student's mind seems elsewhere.					
The student is easily distracted.					
The student has difficulties organising the task, such as deciding what to do, what to draw, and how to organise the drawing and ideas.					
The student avoids engagement in tasks.					
The student forgets daily activities.					
Hyperactivity and Impulsivity					
The student taps his/her hands or feet.					
The student moves in his/her seat.					
The student often leaves his/her seat or does not remain seated.					
The student runs or climbs in inappropriate situations.					
The student finds it uncomfortable to be still for an extended time.					
The student talks excessively.					

Appendix 2: The Pilot Study

1. Introduction

The main aim of conducting a pilot study is to test the validity and reliability of the research instruments and to get feedback regarding the suitability of the instruments. Two apps were used in order to examine SCV and PRV: Keynote was used for SCV and Make It was used for PRV. The pilot study followed the main study's design. It started with a pre-test and pre-test interviews, followed with a multiple baseline experiment, and ended with a post-test and post-test interviews. The observations were collected through videos recorded during the experiment. The challenges encountered and additional information during gleaned from the pilot study indicated the need to make some changes to the main study plan. All of these issues are discussed in more detail in this Appendix.

There were many benefits of applying the pilot study. Conducting the pilot study allowed for a better understanding of the research process by develop an understanding about the research instruments (SCV and PRV) by highlighting the strengths and the weaknesses of each. In addition, the pilot study improved and clarified the research aims and questions by clarifying the application of PRV and SCV and how both work with students to shape their understanding of mathematical word problems. Furthermore, the pilot study suggested some ideas for suitable research design and data collection methods. An example included the addition of open observations to give clear indications about how the students can deal with each problem and how they develop using SCV and PRV. Finally, the pilot study gave a clearer idea and more focus in terms of what the researcher intended to do through the study, which can reflect some elements of validity and reliability of the main study, such as by identifying some of the confounding variables (for example, individual ability differences in mathematics and drawing). In addition, testing the study instruments (for example, the observation sheet) helped demonstrate their ability to fulfil their purpose (for example, observing students' behaviour), and testing SCV helped identify the number of questions required within the timeframe while developing the image quality for PRV to be clear when presenting the word problems.

2. Design of the Pilot Study

The pilot study followed the procedures and design of the main study. Testing the influences of both SCV and PRV on students' ability to solve mathematical word problems occurred through two apps: Keynote for SCV and Make It for PRV. An open-ended observation (qualitative observation) was used as an additional tool for the pilot study in order to acquire more in-depth information about how students can deal with and apply SCV and PRV during the experimental sessions. These observations were collected through note-taking during the sessions for each student (see Table 1).

Table 1: Open-ended observations for SCV and PRV

Visualization	Areas observed
SCV	• The kinds of questions students asked • How they started solving the problems • The first step that they took • The type of drawing they created • The quality of the drawing • Comments they made or asked • Did they solve the problems correctly?
PRV	• If the students understood the given images • Did they look using the given images? • The kinds of questions asked during the sessions • Did they guess the answers or solve the problem? • Did they solve the problem correctly?

The sample for the pilot study was taken from the same two schools as the main study in order the facilitate these schools' participating in the main study, learn more about these schools system, and gain more information about ADHD students in these schools as well as the actual number of ADHD students allocated in both schools. Two girls and two boys between 9 and 11 years old with no ADHD diagnosis were randomly chosen. The reason for choosing non-ADHD students for the pilot sample was because of the limited number of ADHD students available for the main study sample. There was no intention to use ADHD students for the pilot study because the main objective was to test the function of the instruments with children in general. The pilot study lasted 7 days, and the activities were structured as shown in Table 2. These activities will be discussed in more detail next.

Table 2: Pilot study activities

Day	Activity
1	Pre-test and pre-test interviews
2	Applying SCV or PRV (students were randomly allocated to the phases)
3	Applying SCV or PRV (students were randomly allocated to the phases)
4	Applying PRV or SCV (students were randomly allocated to the phases)
5	Applying PRV or SCV (students were randomly allocated to the phases)
6	Post-test and post-test interviews
7	A spare day in case any implications arose while conducting the pilot study

3. Quantitative Methods

3.1. Experimental Design

It was important for the pilot study to test the ability to apply the experiment sessions plan for SCV and PRV for each participant and to test both the pre-test and post-test. Thus, the sessions were designed so that each student had a daily one-to-one session for a maximum of 30 minutes for 4 days. The study was conducted in special schools for students with learning disabilities, which have a different system than other government schools. For example, these schools have the standard school practice of a group class (in which students are taught with their peers by their class teacher following the Ministry of Education’s curriculum plan), but they are different in that they also have additional one-to-one sessions (led by a teacher who is not necessarily their class teacher). The main objective of these one-to-one sessions is to develop the students’ skills and knowledge, following the curriculum plan. The pilot study was conducted in one-to-one sessions. Instruction and clarification were given to the students when they asked for it.

Pre-test, post-test, and session questions were taken from reliable sources for test questions and session questions from the two schools in the pilot study, with the help of both schools' teachers. These questions were divided into five easy questions, three medium questions, and two difficult questions in order to account for students' individual differences and abilities. The students completed three different types of tests, as in the main study, to provide an answer for the first research question (see Table 3). Each student completed both PRV and SCV (see Table 4).

Table 3: Pilot study tests

Test	**Procedure**
Pre-test	Administered before the first session; contained 10 questions.
During the session (PRV or SCV)	Counted the number of right and wrong answers to understand the efficiency of using the PRV and SCV. Each student solved 10 questions
After every two sessions test (4 tests)	Students solved 10 questions to determine the extent of their development of SCV and PRV use.
Post-test	Administered after completing all sessions.

Table 4: Experimental design

Child	**First 2 sessions (Days 1 and 2)**	**Last 2 sessions (Days 3 and 4)**
A	SCV	PRV
B	PRV	SCV
C	SCV	PRV
D	PRV	SCV

3.2 Observations

The (structured) observation form was designed to be suitable for the pilot study's sample size (see Table 5). The main objective for using the observation sheet was to understand to what extent PRV and SCV can affect ADHD students' behaviours by allowing them to remain focused while solving mathematical word problems. As noted in the Methodology chapter, the observation form was developed from the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5) and was used with each child in each of the four sessions. Observations were video recorded. Each observation noted the occurrence of ADHD behaviours; if the behaviour occurred, the researcher marked 1 and if not, 0. Arguably, the sample for the pilot study did not include ADHD students, but it was worth noting if the observations worked well and could be collected from the video recordings.

Table 5: Observations of ADHD behaviour

	Number of sessions			
ADHD behaviour	1	2	3	4
1-Inattention				
Missing details and the work is inaccurate				
Difficulties remaining focused on tasks				
Mind seems elsewhere				
Easily distracted				
Difficulties organising the task				
Avoids engagement in tasks				
Forgets daily activities				
2-Hyperactivity and impulsivity				
Taps hands or feet				
Squirms in the seat				
Often leaves the seat, does not remain seated				
Runs or climbs in inappropriate situations				
Uncomfortable being still for an extended time				
Talks excessively				

4. Qualitative Methods

4.1. Semi-structured Interviews

The semi-structured interview questions were the same as in the main study. Two semi-structured interviews were used; the first one was conducted after the pre-test to understand the students' thoughts about and processes when constructing drawings and solving mathematical words problems in general before carrying out the experiment sessions for PRV and SCV. These pre-test interviews took between 6 and 7 minutes each. The second semi-structured interview was conducted after the post-test to understand the students' perceptions of the tools and if the research tools were successfully used by the students. These took between 12 and 15 minutes each. Both interviews (pre-test interviews and the post-test interviews) were video recorded because of questions 2 and 3 (2. If I give you this word problem (give the student a paper with a word problem written on it), what is the first thing to come to your mind to solve this problem? 3. For the same word problem (written on the paper), can you explain how you would solve it?) of the interview, as it was assumed that the student would need to create a drawing, and to understand how the student dealt with the given word problems.

4.2 Open-ended Observations

Open-ended observations were utilised in the pilot study to observe students in the experimental sessions in order to understand how they deal with and apply SCV and PRV. The process involved taking notes about what happened with the students for each question (see Table 4.2) and how the students solved the mathematics word problems for both PRV and SCV. For example, for PRV sessions the observation notes focused on whether the students understood the given pictures, looked at the given pictures, asked questions during the sessions, guessed the answers or really solved them, and solved the problems correctly. In SCV sessions the observation notes mostly focused on the kinds of questions asked, how they started solving the problems, what the first step was, what type of drawing they created, the quality of the drawing, what comments they made or asked, and whether they solved the problems correctly.

5. Challenges and Implications of the Pilot Study

The implications of the pilot study could be categorised into challenges and recommendations for the main study.

5.1 Abandoning the Study

One of the challenges that might affect the main study is ensuring that all participants continue to attend the sessions. In the pilot study, half the sample (i.e. two out of four students) abandoned the study. One student left because she did not like drawing and refused to draw. In addition, individual differences in drawing ability, mathematics ability, and technology use preferences were obvious. The open-ended observations indicated that students were confused about the type of drawings that they needed to create, which might make the idea of drawing difficult for some students. These examples reflect some elements of validity and reliability of the main study. For example, identifying some of the confounding variables, such as individual ability differences in mathematics and drawing, can help determine validity and reliability. The other student left because he refused to be video recorded even after the researcher explained that she would stop the recording once he left the study. Such issues were reflected in the interviews, as some students were confident and cooperative while others were shy and hesitant to take part in the interview.

All of these issues indicated the need to provide more clarifications for participants both groups (i.e. SCV and PRV) about the nature of the study and what they are involved in before signing the consent form and starting any of the study activities. This realisation led to the idea of having an introductory session for the SCV group (the intervention group) about what kind of drawings to create, which can aid in accurately measuring (Bernard, 2017; Green & Thorogood, 2018) a public artefact that helps students do mathematical word problems better. The main objectives of the introductory session are to ensure that the students understood what creating or constructing a drawing means and to solve any confusion regarding their use of the instrument. This session will be conducted before the first intervention session and will last 10 to 15 minutes. The factors to be discussed in the introductory session include:

- What does 'creating a drawing' mean?
- What kind of drawing should the students create?
- To what extent should the students' drawing provide a translation for the word problem?
- How can they draw using the Keynote app?

This information can help children create their own images and drawings to visualise word problems.

5.2 Reading Support

Another challenge was students' reading ability, which was weak. The researcher had to read most of the word problems for the students. It was not the intention to provide reading support for each problem in the main study, but after pilot study it was decided that it would be better to provide equal support to each student by reading the word problem to ensure the reliability and the validity of the data.

5.3 Timing of the Sessions

Choosing suitable questions and designing the sessions especially, for PRV, required a lot of thought, preparation, and time. For example, the pictures have to provide a good translation for the word problems, and collecting pictures is time-consuming as the researcher has to search for appropriate pictures for each question. The researchers also needed to consult with other teachers to ensure that the pictures presented the problems perfectly. However, for SCV, the researcher only had to think about the questions. Based on this experience, more teachers needed to be involved in consultations, and more time was allotted for session preparation.

Regarding the timing of the sessions, 30 minutes was sufficient to solve 10 word problems in PRV sessions, but not in SCV sessions, where students needed to construct drawings. The pilot study helped identify the timing issues with SCV sessions. To address this issue, the number of questions in the main study will be reduced to 6 for the pre-test, post-test, PRV sessions, SCV sessions, and session exams.

5.4 Inclusion of Open-ended Observations

Open-ended observations were applied in the pilot study for each student during the experimental sessions to understand in more depth the extent to which students can benefit from applying SCV and PRV in mathematical word problems. These qualitative observations can help underscore more information and responses about both PRV and SCV practices (Green & Thorogood, 2018). For example, they helped realise that the pictures for PRV need to be clearer and more understandable because students asked a lot of questions and seemed confused at times. In addition, the observations helped understand the drawing-related issues, resulting in the inclusion of an introductory session for the intervention group. This observation was not part of the main study design, but it will be applied because it can help answer the first research question by providing more information about how SCV helps students solve mathematical word problems compared to the use of PRV.

5.5 Changing the Experimental Design of the Main Study

The information gleaned from the pilot study about the number of ADHD students was higher than expected. The expected number was between 6 and 10 students, but the real number is 30 to 35, which led to some changes in the research plan for the main study, especially regarding the experimental design. A multiple baseline design was adopted for the experimental design without having a control group because of the small sample size. However, in light of the updated information about the number of ADHD students, the design will be changed to an intervention design. Coe et al. (2017), and McMahon, Griffith, Mariani and Zyromski (2017) defined the intervention design as an experimental design aimed at determining the impact of the specific treatment or practice by making changes through the manipulation of the effect of that treatment or practice on two equal randomised groups. Randomising can help ensure a fair comparison between groups (Coe et al., 2017).

The intervention design for the current study contains two equal group: the intervention group (SCV) and the comparison group (PRV). The students will be randomly allocated into these two groups according to their pre-test scores (high, mid, and low), so that each group contains students with high, mid, and low scores. The students in both groups will use both apps for SCV and PRV for the same length of time (5 weeks, or 25 sessions). This will demonstrate the effect of using SCV to solve mathematical word problems for each ADHD student.

Table 6: Control group (PRV): 7 girls and 10 boys

Week	Sessions
1	1–5
2	6–10
3	11–15
4	16–20
5	21–25

Table 7: Intervention group (SCV): 7 girls and 10 boys

Week	Sessions
1	1–5
2	6–10
3	11–15
4	16–20
5	21–25

This intervention study by group comparison experiment will not only help address the efficacy and effectiveness of using SCV as an intervention with ADHD students solving mathematical word problems, but can expand the knowledge of educational practice by improving mathematical achievement, cognitive abilities, and efforts to manage ADHD behaviours. Adopting intervention research can help improve the findings and outcomes by providing a clear picture about the effect of implementing CV on ADHD students' mathematical abilities and managing their behaviours, compared to PRV, by using a standardized measurement (Tau-U). Tau-U is a statistical approach used to assess the effect size by controlling the baseline trend, assessing the trend across the intervention phases, and controlling the properties of the data from the intervention phases (Chen, Peng, & Chen, 2015). Thus, that intervention research offers many advantages for assessing the effect and impact of the intervention (i.e. SCV) and improving the finding of the study instruments by increasing the ability to manipulate the changes on ADHD students' mathematical ability and behaviours.

6. Summary

This chapter presented a review of the pilot study, which included describing the pilot study's research design by presenting the quantitative and qualitative methods. In the last section of this chapter, the implications of the pilot study were addressed by highlighting some challenges faced during the pilot study and making recommendations for the main study.

Appendix 3: Note-taking during the Intervention

Examples of Notes Taken for SCV and PRV

Guidelines for notes for SCV and PRV

Visualization	Areas observed
SCV	• The kinds of questions students asked • How they started solving the problems • The first step that they took • The type of drawing they created • The quality of the drawing

	• Comments they made or asked • Did they solve the problems correctly?
PRV	• If the students understood the given images • Did they look using the given images? • The kinds of questions asked during the sessions • Did they guess the answers or solve the problem? • Did they solve the problem correctly?

Daily notes from week two for one PRV student

Day	Notes for each session
Day 1	-She used the picture very well to count. -She looked at the picture, but she did not look as if she was using it. -She used the picture to count the objects. -She said: "This picture is so clear to represent the problem." She used it well to solve the problem. -She looked at the picture for a second and directly chose the answer; maybe she guessed it. -She did not look at the picture. She said, "I did not understand it." Then she picked the answer; maybe she guessed it.
Day 2	-She said, "I did not understand the picture." -She picked an answer; she guessed it. -She used the picture to count. -She used the picture to count. -She understood the problem, saying, "This is division." I am not sure if she used the picture. -She looked confused and said: "I will guess." -She did look as if she was sure about what to do. She said, "I did not understand the problem." She looked like she guessed it.
Day 3	-She said: "I did not understand it." She looked like she guessed it. -She used the problem to count. She said: "I did understand it." She talked with me about how to solve the problem. She showed a good understanding. -She said: "This is confusing." She looked like she guessed the answer.

	-She did not look like she used the picture. She looked like she was guessing the answer. -She said: “This is difficult.” She looked like she guessed the answer. -She used the picture to count. She showed a good understanding.
Day 4	-She did not look like she was using the picture because she selected directly, and it was the wrong answer. -Again, she looked like she was guessing. -She said: “This is confusing.” I saw her using one part of the picture and then forget to use the second part. She missed the detail from the picture. Then she picked the answer. -She said: “This is easy.” Then she picked the answer. -She said: “This a tricky question.” She looked like she guessed the answer. -She looked confused. She kept looking at the picture, but she did not look like she understood it. She guessed.
Day 5	-She used the picture very well and showed a good understanding of the type of the problem. -She looked at the picture, and she used it to understand the problem. -She used the picture. She counted the items in the picture. -She said: “I am confused.” After she looked, she guessed it. -She used all the information in the picture very well. -She said: “I did not understand the problem.” She looked like she guessed.

Daily notes from week one for one SCV student

Day	Notes for each session
Day 1	-She represented the problem perfectly by drawing. -She tried to represent the problem. She said: “This is difficult.” She guessed the answer. -She looked tense because of the big number in the question. She said: “This big. I cannot.” She tried her best to establish a drawing, but the answer was wrong because she missed a lot of details in her drawing. - She represented the problem by drawing circles, but she failed to reach the correct answer.

	-She was confused about the words in the problem. She asked for clarification, and I read it for her many times. -She drew the problem 4 times to create a representation for the problem, but she kept failing to count the drawing objects.
Day 2	-She did not feel confident. She said: “I cannot draw it.” Thus, I gave her a lot of support to draw and solve the problem. -In this question she looked like she knew what to do. She drew circles to represent the problem. -She asked me: “Is it okay to draw only circles?” I said, “Yes.” Her drawing represented the problem well. -She was not sure what to do or what to draw. She tried her best. She said: “I cannot do better than this.” -She represented the problem perfectly in her drawing, but she did not count her items correctly. -She did not look like she understood the problem because the representation and the answer were wrong.
Day 3	-She tried to draw. She was confused to some extent. I tried to encourage her to continue drawing. She listened to me and started solving the problem correctly. -She represented the problem very well by drawing circles. -She tried to draw a picture to represent the problem. She used an adding strategy to solve it, and she succeeded. -She wrote the right equation. She drew to represent the problem. Her drawing did miss some important details. -Time ran out. -Time ran out.
Day 4	-She knew the type of operation. She represented it by drawing. She said: “I am counting too many, I can simplify it.” -She represented the problem by drawing. She counted her drawing items incorrectly. -She said: “This is difficult.” She wrote the correct equation. She tried to represent it, but she said: “I will not solve it.” -She said: “This is too many to count, so I will not solve it.” She wrote the equation and drew some circles. -She wrote the equation and represented it by drawing it correctly. -She wrote the equation, then she said: “This is easy.”

Day 5	-She tried to represent the problem by drawing, but she missed counting the items in her drawing. -She understood the problem. She represented it by drawing. She wrote the equation and solved it. -She was so focused when entering the items of the drawing and counting them. -Time ran out. -Time ran out. -Time ran out.

Appendix 4: Students' Perceptions According to Themes and Codes

Perceived Advantages and Disadvantages of SCV

Codes	1.1 Advantages SCV students	PRV students	Codes	1.2 Disadvantages SCV students	PRV students
1.1.1 Help in providing information about mathematical word problems	3-B-SCV: "Let us suppose that once I do not have a picture, so drawing is better where I can provide myself with all information that I need to solve the problem"; "I have the answer after I draw every information in the problem, so I have all the problem information"; "yes, the drawing was clear by	7-G-PRV: "Drawing is clearer than solving by my fingers, because all information is provided"	1.2.1 Physical discomfort when drawing	2-B-SCV: "Because by using pictures I will not get as tired as doing the drawing" 4-B-SCV: "Also drawing too many pictures sometimes gives me a headache" 6-G-SCV: "A lot of questions to be drawn	1-B-PRV: "Doing drawing was nice, but doing too much drawing by using colours might hurt my hand, similar to do too much writing"; "Because drawing can take too much time and makes me tired" 2-B-PRV: "In addition, it gave me a headache when I tried to do it

	providing all information about the problem” 6-G-SCV: “Yes, I know how to solve but not well, but by using drawing all information is there” 7-G-SCV: “I used some drawing for the difficult problems because drawing can provide all the problem information” 8-G-SCV: “I solve it by using drawing, because it can make the problems’ information accessible”			hurts my hands”; “also too much drawing can give me a headache”; “Because using pictures did not hurt my hand”; “without hurting my hand by creating the drawing” 8-G-SCV: “and sometimes when I did too much drawing, I had a headache”	because there were too many problems to be solved” 5-G-PRV: “I didn’t like drawing because it hurt my hand”; “In some situations I might choose to use pictures because my hand hurts me when I draw too many questions” 6-G-PRV: “Because I do not like drawing. It makes me tired”
1.1.2 Help in visualising mathematical word problems	1-B-SCV: “Now I can use drawing to add everything in the problem and solve it”; “drawing helped me to answer the problem and find the solution”; “I	3-B-PRV: “While I am solving the problem, I draw squares and read to find the solution” 6-G-PRV: “Because I can see the	1.2.2 Dislike of drawing	2-B-SCV: “It is better than using drawing” 4-B-SCV: “I like using the picture” 5-G-SCV: “I prefer seeing pictures and	1-B-PRV: “Seeing a picture was better” 2-B-PRV: “I did not like to use drawing, it was a little bit difficult”; “I do not know how to draw so I do

	have to draw to see the problem"; "yes, so everything will be in front of my eyes"; "I can see everything clearly in the problems and I can get the correct answer"; "if the problem is difficult, I can draw everything until I reach the answer, so drawing was very useful to get the problem answer" 2-B-SCV: "while drawing I can see everything in the problem. For example, I can draw four cars and each car have four passengers, then I can count them all" 3-B-SCV: "I was using circles as sets, this made everything visible for me to solve the problem"; "in order to solve	problem by using drawing" 7-G-PRV: "Because drawing is clear for me by seeing the problem information"		solving, because it easier than drawing" 6-G-SCV: "I do not love it"; "No, it did not teach me anything"; "no, I still did not know what to do"; "I will choose using pictures" 8-G-SCV: "Because it is easier than drawing"	not prefer to draw" 3-B-PRV: "I prefer seeing pictures"; "No, I did not like drawing to solve mathematical word problems"; "I prefer the one which has pictures" 4-B-SCV: "I could not solve it by drawing because I did not train to draw to solve mathematical word problems" 5-G-PRV: "I didn't like drawing" 6-G-PRV: "I don't like drawing"

	the problem, I draw circles as the taxies, and for each taxi I draw 4 people"; "By drawing circles, I can see everything clearly, so I can solve it correctly" 4-B-SCV: "Drawing helped me to see all the problem information clearly" 6-G-SCV:" I draw it to see everything in the problem and solve" 7-G-SCV: "I can focus now by seeing the information of the problem through the drawing"; "I used some drawing for the difficult problems because drawing can provide all the problem information in front of your eyes"				
			1.2.3 Cognitive	5-G-SCV: "In drawing	1-B-PRV: "Because I do

	load when drawing	I have to do everything by myself and this takes too much time and mental effort compared to using pictures"; "pictures were easy for me; it did not require as much thinking as drawing" 6-G-SCV: "Drawing needs too much thinking, this gives me a headache"; "I meant by saying 'without effort' is without thinking too much about what to draw" 8-G-SCV: "By using pictures I can't get nervous or confused because the drawing is there, so I do	not have experience in using drawing, so in order to do the drawing I need to think how" 2-B-PRV: "I do not know how to use it and it requires a lot of thinking about what to draw and how to solve the problems"; "It was a little difficult and required a lot of thinking" 3-B-PRV: "Because it was difficult, it required deep thinking and I did not know what I have to do exactly" 6-G-PRV: "I never used drawing before, so I do not have experience drawing when solving mathematics, and I need to squeeze my brain in order to do one

		not need to think about what to draw or what to do”	drawing for one problem”
	1.2.4 Time-consuming to draw images	4-B-SCV: “Because using pictures is easier than drawing in getting the answer and faster”; “Because using pictures is easy to understand and it did not require a lot of time like drawing”; “I did not finish all the questions. I needed time to draw them all” 5-G-SCV: “In drawing I have to do everything by myself, and this takes too much time” 7-G-SCV: “I will not have time to draw, this is faster than drawing”;	1-B-PRV: “Because drawing can take time, and I did not have the experience to use it”; “In the beginning, I thought about using drawing but later I told myself counting mentally is better because drawing might take time”; “Because drawing can take too much time and makes me tired” 2-B-PRV: “The drawing can take a lot of time to be created”; “Yes, I prefer counting mentally instead of doing drawing because drawing takes time” 3-B-PRV: “Yes, counting by hand is easier and

				"The easy way is by solving them quickly without drawing, because drawing can take time"	faster than doing a drawing" 4-B-SCV: "This way is easier than drawing, drawing will take time"; "drawing was a good strategy, but I did not finish all the questions. I needed more time" 8-G-PRV: "Pictures did not take time in thinking about what to draw"

Perceived Advantages and Disadvantages of PRV

	2.1 Advantages			2.2 Disadvantages	
Codes	SCV students	PRV students	Codes	SCV students	PRV students
2.1.1 Help in providing information about mathematical word problems	4-B-SCV: "Because pictures can give me all information that I need without drawing" 6-G-SCV: "Pictures can provide all the problem information clearly	1-B-PRV: "It helped to understand the picture first and provide me with the important information about the problems" 4-B-PRV: "When you give me the pictures and	2.2.1 Cognitive load when preserving pictures		4-B-PRV: "I did not like it, because it required a lot of effort in looking and thinking about the picture and what information is there and if this information

	without effort”	the questions, I look and then I start to think about how to solve the problem through the picture’s information” 7-G-PRV: “Yes, because pictures were clear by providing all the information that I need to find the answer”			is useful or not” 5-G-PRV: “I will not recognize what the picture is about. Sometimes pictures require a lot of thinking” 6-G-PRV: “Because it was difficult to look at a picture and try to understand it”; “most of the pictures I did not understand them. I needed to think a lot about the content of the picture”
			2.2.2 Time-consuming to process given images	3-B-SCV: “Also, I need time to understand the picture content”	5-G-PRV: “Some pictures were not clear for me, so I needed too much time to think about the content of the picture” 6-G-PRV: “Because thinking about the

					content of the pictures can take a long time”
2.1.2 Help in visualising mathematical word problems	5-G-SCV: “Because the drawing is quite different than pictures. In pictures the drawing is there” 8-G-SCV: “No, not guessing, but everything is in front of your eyes, this makes it easier for me to see all of the problem information”	1-B-PRV: “I imagined six cars, then I put four persons then and I count them four times”; “Honestly, yes, using pictures helped me a lot, especially in visualizing the problems” 2-B-PRV: “I can think better now by imagining what the problem looks like”; “I can see the problem through the pictures clearly” 3-B-PRV: “I read then I understand the problem through the picture”; “Yes. When I saw the picture, I knew the answer because I can see everything related to the problem”; “I want pictures to see the	2.2.3 Given images are not useful	1-B-SCV: “It is easier for me to do everything by myself. Using pictures might not have everything I need” 3-B-SCV: “Let us suppose that once I do not have a picture, so drawing is better where I can provide myself with all information that I need to solve the problem”; “I can solve it by using pictures but it may be wrong because pictures were not clear for me”; “Sometimes it did not give me what I need, but this was not the case for all pictures, some of them were good”; “it did not give me what I needed,	5-G-PRV: “Yes, I can understand my drawing better than giving me a picture”; “I will not recognize what the picture is about”; “Some pictures were not clear for me” 6-G-PRV: “Because it was difficult and I did not think that it was beneficial for me”; “no, I did not learn by using pictures”; “it did not help me to solve the problems” 7-G-PRV: “Because drawing can help in growing my mind by being able to think about

	problem clearly” 4-B-PRV: “When I saw the picture, I started to think about what the solution could be”; “I started to think about the picture’s information, after that I can have the solution”; “I think they need the total, so I imagined that my fingers were the taxis then I started to add them all”; “yes, I have a picture in my mind and my fingers are the taxis” 5-G-PRV: “Yes, I can understand the problem because I can see it” 7-G-PRV: “The picture helps me with the result by seeing everything through the pictures”	I mean the information that I needed to solve the problems”	the problem, but in pictures I only need to see and solve”; “yes, drawing is more important than seeing pictures, because pictures are not present all the time for me”

	8-G-PRV: "Because I have to create everything by myself, but in pictures everything is in front of my eyes"	

Appendix 5: Teachers' Perceptions

Theme 1

Code	SCV teachers' perceptions	PRV teachers' perceptions
1.1 Perceived impact on students' ability to solve mathematical word problems	1-B-SCV: For example, if we are applying a thing on the issue he is not answering but **he draws**… for some difficult problems 2-B-SCV: Uses some of the strategies that I use with him to solve the problems 3-B-SCV: He solves the problem **by drawing** 4-B-SCV: I can see that in his textbook he is **using drawing** for the difficult problems 5-B-SCV: I have noticed that he is relying **on drawing** to solve the problems 6-B-SCV: He did not use any strategy for solving… especially in the word problems he has to understand the word to be able to solve. 7-G-SCV: The student is improving by **using drawing** where on her test she was planning and drawing	1-B-PRV: The student started to do some **drawing** to solve mathematical word problems 2-B-PRV: The student's ability to solve the problems is improved by using drawing such as lines, circles, and elements 3-B-PRV: The student did not improve, he is still making the same mistakes 4-B-PRV: The student developed in solving mathematical word problems because he is thinking and more organised 5-B-PRV: The student's understanding of the problems improved 6-B-PRV: By using drawing, his understanding of the word problems is improved 7-G-PRV: The student improved in mathematics

	8-G-SCV: Yes, I believe **she did for the division.** 9-G-SCV: The student is more confident in dealing with mathematical word problems by being very committed with steps and dealing with the problem **as a story** 10-G-SCV: she is **using the drawing** for solving the problems.	8-G-PRV: The student shows better performance than before to solve the problems. 9-G-PRV: [The student] did not show any development 10-G-PRV: The student showed an improvement and the student's grade increased
1.2 Perceived impact on students' effort in solving mathematical word problems	1-B-SCV: He did not provide answers, but he is trying to draw. Sometimes I noticed that he started to highlight all the given information 3-B-SCV: Yes, there is a change in his strategy in solving the problems. He is solving the problems **by drawing** 4-B-SCV: I can see that in his textbook he is **using drawing** for the difficult problems in order to try to solve them 5-B-SCV: I have noticed that he is relying on drawing to solve the problems. Before he did not even try 6-B-SCV: No, the tool was not effective because the student did not try to use any strategy for solving 7-G-SCV: I have noticed that she is **using drawing**. I have noticed on the test, she is planning and drawing as	1-B-PRV: For example, if I give them a problem to solve in multiplication or division, he **puts circles** and divides them to the points or lines, this surprised me. 2-B-PRV: I can see more effort and motivation. He is trying to be part of the class by trying to solve the problems that I gave in the class 4-B-PRV: Exactly, now he knows that there is nothing difficult if we focus and think we can get the answer; thus, he is participating more than before. 5-B-PRV: He is trying to provide an answer 6-B-PRV: I can see that he is thinking and trying to understand how to solve things. He stopped saying "I do not want to solve". Now he is trying

	ways to try to solve the problems. 8-G-SCV: I believe she did try for the division. 9-G-SCV: I have seen how the student has changed. Even in her free time she comes to me to understand how to solve some problems. She has become more diligent. 10-G-SCV: She is starting to use **drawing** especially for multiplication and division	7-G-PRV: Yes, she is trying to solve, especially when I gave her a division problem, she solves it **by drawing** 8-G-PRV: I have noticed drawing circles with elements to solve some difficult problems. Her performance has become better than before, especially in the recent period where her participation increase, and she is trying to solve the problems
1.3 Perceived impact on student engagement while solving mathematical word problems	3-B-SCV: I think yes, she is developing and more engaging with me. During this course I have noticed that her concentration and attention have become better than in the beginning of the course. 5-B-SCV: I have noticed that he has started remembering things and is more organised. He is participating more. 7-G-SCV: I think yes, she is developing and more engaging with me. During the course I have noticed the difference in her concentration and attention has become better than in the beginning of the course. 9-G-SCV: I have seen how the student changed. Even in her free time, she comes to me to understand how to solve some problems. She became more diligent. She is	1-B-PRV: Of course, because the boy did not try to solve any problems with me, and he was not responding before. 2-B-PRV: Of course, because the boy is totally changed, he started to love the subject and trying to improve himself, also he is trying to solve the problems. It gave him the strength the trust in himself. 4-B-PRV: He started enjoying mathematics class and he started participating in solving the problems and engaging with other students; before he was isolated. 5-B-PRV: His confidence and engagement are almost more increased than before 6-B-PRV: Maybe it is effective because he stopped saying “I do not want to solve”

	more motivated to be a part of the mathematics class 10-G-SCV: It is successful because the student is better than before in solving mathematics problems and I can see more effort from her.	8-G-PRV: Her performance has become better than before, especially in the recent period when her participation become better and she is trying to solve the problems

Theme 2

Code	SCV teachers' perceptions	PRV teachers' perceptions
2.1 Perceived impact on inattention behaviour	1-B-SCV: For example, if we are applying a thing on the issue, he is not answering but he is drawing and sometimes I noticed that he was trying to highlight all the given information. Maybe, this is how he tried to be **more focused**. 5-B-SCV: Look, honestly, I have noticed that the student has totally changed. I have noticed that he has started **remembering things**, is more organised, and I have noticed that he is relying on drawing to solve the problems. Exactly, exactly, last week our lesson was about word problems, and for the first time I did not need to remind him how to solve the problems, I just gave him the multiplication table as usual. I was surprised that his ideas were organised. He was not like this before. 6-B-SCV: No, there is no change, he is still distracted and sometimes he is shaking his leg. He is the same	1-B-PRV: No, I did not feel that the student's behaviour has been changed. I mean, no change or trying to control the behaviour 2-B-PRV: He has become **more focused** and participates more in the class, he wants to improve himself and tries to solve problems. His **lack of attention decreased** a lot. 3-B-PRV: I've noticed that his **focus has become better.** Exactly, he is focusing, and the movement honestly has become less 4-B-PRV: Because he has started to be **more focused** and because he is focusing now, he has a **better understanding.** 5-B-PRV: After your study, he developed himself by becoming **less distracted** and his **focus has increased**.

	student as before, and I did not notice him trying to do anything to control himself 7-G-SCV: I felt that her **attention became better**. She tries to control herself, she tries to think, and she has become more patient. **Her concentration has become better. Even forgetting has become less.** 8-G-SCV: I did not notice any change in her behaviour or her performance 9-A-SCV: Her **focusing has become better** than before. For example, for the long division I can see that she is very committed to the problem steps and very organised. 10-G-SCV: Yes, it is less, she is **paying attention** now, and not talking without permeation. Yes, **her focus is better**	6-B-PRV: I do not think that he has reached any level of controlling his behaviour yet. 7-G-PRV: I do not think so, or maybe I did not pay attention to that. Thus, I did not notice it 8-G-PRV: No, I believe she can't control her behaviour, because it is something beyond her control 10-A-SCV: But maybe her **attention has become better,** that is why her performance became better
2.2 Perceived impact on hyperactivity/impulsivity behaviour	2-B-SCV: Let's say a little not too much…. Sometimes he moves, **he must move**. 3-B-SCV: When he was moving and playing with the pen, he noticed himself and **stopped moving**. I mean these things became less. He is **not moving out of his place;** he is focused on trying to enjoy the class by concentrating and complying with my standards and solving	3-B-PRV: I've noticed that his focus has become better. Exactly, he is focusing, and the **movement honestly has become less.** 4-B-PRV: There is a huge change, I was using the circle to control his **movement**, but after your study I do not need it. He makes his own boundaries. Before he was always **shaking his leg** or kept **opening and closing the pen**, but now I have not

4-B-SCV: No, it did not become less, he still **shakes his leg**

5-B-SCV: Look, honestly, I have noticed that the student has totally changed. I have noticed that he has started remembering things, **is more organised**, and I have noticed that he is relying on drawing to solve the problems. Exactly, exactly, last week our lesson was about word problems, and for the first time I did not need to remind him how to solve the problems, I just gave him the multiplication table as usual. I was surprised **that his ideas were organized**. He was not like this before.

6-B-SCV: No, there no change, he is still distracted and **sometimes he shakes his leg**, nothing has changed. He is exactly the same, and I did not notice him trying to do anything to control himself.

7-G-SCV: Even **the aggressive behaviour** with other girls has become less

8-G-SCV: I have not noticed anything in her behaviour or in her performance

9-G-SCV: Her focus has become better than before. For example, for the long division I can see that she is very **committed to the** noticed any of these. He can understand orders like **sitting in the chair not on it**.

9-G-PRV: Not at all, nothing changed, the **movement** is the same and she is **still sitting on the chair**

10-G-SCV: No, the **movement** in class stays the same but her level in math improved; even her grades increased at the end of the semester.

	problem steps and very organised. 10-G-SCV: Yes, it is less, she is paying attention now, and **not talking without permission**	

Theme 3

Code	SCV teachers' perceptions	PRV teachers' perceptions
3.1 Perceived benefits of SCV	1-B-SCV: First thing, I feel pictures are more fun for the child than drawing. Second, he will use his imagination and let him make a little effort to fill his brain with a clear translation of the problem. For example, getting out of depression or from inactivity; this way is better and nicer 2-B-SCV: Because he should learn to use his imagination even if he drew incomprehensible things. Of course, he will benefit a lot 3-B-SCV: Exactly, before there was no self-confidence or concentration, and there was no love for the class. But after I found out that you are including him in your plan there is a change in improvement… Also, there are many other things such as focus and enjoying the class. I did not use your strategy, but I hope that we will use it because it will benefit us 4-B-SCV: It is a good strategy, but the students need	1-B-PRV: By using pictures the problem becomes entrenched in their minds better than drawing, because they can see a clear visual translation of the problems 2-B-PRV: Researcher: Do you think if I applied the opposite with him and give him drawings not pictures, the same result will occur with Ibrahim? Teacher: I noticed with the drawings more than the pictures Researcher: So, he watched pictures but used drawings which means the picture helps him draw Teacher: Exactly 4-B-PRV: Maybe because of the hyperactivity that he has, so using drawing is a way where he can waste his extra energy. It makes him more focused and control his movement. I think he is focusing on his hand while drawing. Sometimes the pen is so dark or broken because he is putting all his energy on it

	practice to master it or understand it 6-B-SCV: No, it was not effective because he did not use any strategies for solving. It depends on the student and the lesson; if it is simple then drawing because the lesson is easy and the numbers will be small, but if the lesson does not work with drawing and the numbers are huge neither pictures nor drawing will work 7-G-SCV: Yes of course. But I **need to understand it first** because I am not sure what your strategy is exactly. I understand that it was using drawing…. Yes, I have noticed the difference, I do support your way 8-G-SCV: Yes, and I do use it, but students should have **training about how to use it** correctly 9-G-SCV: I do support this way because it can facilitate the problems 10-G-SCV: Yes, drawing is useful to write the mathematical phrase and find the solution. It is successful because the student is better than before… For these students it is a good thing to use because it helps to deliver the information easier	5-B-PRV: I might use drawing because it can provoke their thinking, but as I mentioned before, pictures are much better than drawing where they may draw something not related to the problem and get the wrong answer 6-B-PRV: If I have to choose, I will choose pictures because it is easier and faster because I have to commit class time. For word problems, maybe it is better for the student to draw to show his understanding, but I might also use pictures if the time is limited 7-G-PRV: I will choose drawing because it shows the students' understanding of mathematical word problems. If the student struggles to draw, then I will give a picture and make the student think… Because information can be communicated better by drawing 9-G-PRV: Drawing can be beneficial by showing the students' understanding of the problems, but in Abiar's case I do not think it will work **because she is very hyper; thus, she cannot sit and draw** 10-G-PRV: Honestly, drawing can be useful, but it **needs a lot of training** about how to draw and what to

		draw. Therefore, if I have to choose, I will choose pictures because it easier and clearer and does not require a lot of effort
3.2 Time Factor	4-B-SCV: I will use pictures because it fits with class time 5-B-SCV: …and if they do not like it, they will take lots and lots of time to draw because they do not have the visual imagination 6-B-SCV: Also, it depends on the class time, if it fits for drawing because as you now drawing can take a lot of time	3-B-PRV: So that can take more time for the students who do not like the drawing. They will take time to think about what they have to draw; thus, I prefer pictures. 5-B-PRV: So, I saw that the pictures can make him remember or not forget and originally benefit me in the class

	7-G-SCV: But also, I need to consider that drawing might take time, thus providing enough time for this strategy is important 8-G-SCV: I do not have ADHD, but I do not like drawing. I like colouring but not drawing, and if you want me to draw you need to give the time that I need 9-G-SCV: …and it will not take time like drawing 10-G-SCV: I will use it if I have enough time in class	and he does not take a long time to understand. I felt that the drawing takes a long time, so I resorted to the picture 6-B-SCV: As I told you in our last talk, the drawing is useful, but it did take time, and the class time as you know is very short. 9-G-PRV: …and if she did sit and draw, I believe this might take all the class time to draw one or two problems 10-G-PRV: Do not forget that drawing can take time to be done
3.3 Students' perceived preference of drawing	4-B-SCV: I will use pictures because it fits with class time and because not all students love drawing 5-B-SCV: I am not sure Saud loves drawing, but for those who do not love it, I am not sure…. It needs practice, I think 6-B-SCV: In addition, it depends on the student… some of them are visual students, we can use visualization with them, but for those who do not have visual ability I am not sure. It depends on the child himself and what he prefers 8-G-SCV: The problem as I told you, your way cannot be used in every learning situation. There are some learning	3-B-PRV: Maybe only for the students who love drawing 4-B-PRV: I think it can fit with all cases as him, but for some cases who do not love drawing maybe it will not work. I would prefer drawing for the easy problems for the visual students only 7-G-PRV: Yes, I think so, because she likes drawing 8-G-PRV: In the case of this student, I think it will work because she likes to draw

	situations where your way can not be successfully used…. From my point of view for ADHD the tangible thing is better to release their energy 9-G-SCV: …but not every student can draw…. Picture, because students can use it better than they create drawing. Externalization by drawing is better than just seeing a picture, but it depends on the student's level and ability	

Appendix 6: Surveys

Survey of ADHD Students' Mathematics Ability before the Intervention

Indicate the student's mathematical abilities **before the study**. Tick (√) your answer, where 1 is *Totally disagree*, 2 is *To some extent I disagree*, 3 is *I am not sure*, 4 is *To some extent I agree*, and 5 is *Totally agree*.

Questions	1 Totally disagree	2 To some extent I disagree	3 I am not sure	4 To some extent I agree	5 Totally agree
The student cannot identify the type of mathematical operation (i.e. division or multiplication) in most word problems.					
The student is able to provide a solution for most mathematical word problems.					
The student did not use any drawing strategies to find the solutions.					

Survey of ADHD Students' Mathematics Ability after the Intervention

Indicate the student's mathematical abilities **after the study**. Tick (√) your answer, where 1 is *Totally disagree*, 2 is *To some extent I disagree*, 3 is *I am not sure*, 4 is *To some extent I agree*, and 5 is *Totally agree*.

Questions	1 Totally disagree	2 To some extent I disagree	3 I am not sure	4 To some extent I agree	5 Totally agree
I noticed an improvement in the student's mathematical performance in general.					
The student can identify the type of operation (i.e. division or multiplication) in most word problems.					
The student is able to provide a solution for most mathematical word problems.					
The student is using drawing strategies to find the solutions.					

Survey of ADHD Behaviour <u>before</u> the Intervention

Indicate the student's ADHD behaviour **<u>before the study</u>**. Tick (√) your answer, where 1 is *Totally disagree*, 2 is *To some extent I disagree*, 3 is *I am not sure*, 4 is *To some extent I agree*, and 5 is *Totally agree*.

Questions	1 Totally disagree	2 To some extent I disagree	3 I am not sure	4 To some extent I agree	5 Totally agree
Inattention					
The student is missing details.					
The student's work is inaccurate to some extent.					
The student is facing difficulties remaining focused on tasks.					
The student's mind seems elsewhere.					
The student is easily distracted.					
The student has difficulties organising the task, such as deciding what to do, what to draw, and how to organise the drawing and ideas.					
The student avoids engagement in tasks.					
The student forgets daily activities.					
Hyperactivity and Impulsivity					
The student taps his/her hands or feet.					
The student moves in his/her seat.					
The student often leaves his/her seat or does not remain seated.					
The student runs or climbs in inappropriate situations.					
The student finds it uncomfortable to be still for an extended time.					
The student talks excessively.					

Survey of ADHD Behaviour <u>after</u> the Intervention

Indicate the student's ADHD behaviour **<u>after the study</u>**. Tick (√) your answer, where 1 is *Totally disagree*, 2 is *To some extent I disagree*, 3 is *I am not sure*, 4 is *To some extent I agree*, and 5 is *Totally agree*.

Questions	1 Totally disagree	2 To some extent I disagree	3 I am not sure	4 To some extent I agree	5 Totally agree
Inattention					
The student is missing details.					
The student's work is inaccurate to some extent.					
The student is facing difficulties remaining focused on tasks.					
The student's mind seems elsewhere.					
The student is easily distracted.					
The student has difficulties organising the task, such as deciding what to do, what to draw, and how to organise the drawing and ideas.					
The student avoids engagement in tasks.					
The student forgets daily activities.					
Hyperactivity and Impulsivity					
The student taps his/her hands or feet.					
The student moves in his/her seat.					
The student often leaves his/her seat or does not remain seated.					
The student runs or climbs in inappropriate situations.					
The student finds it uncomfortable to be still for an extended time.					
The student talks excessively.					

Appendix 7: Reliability Test

Table 1

Item reliability test before the intervention

Survey Items	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
1. Solving mathematical word problems		
Q6.1. The students cannot identify the type of mathematical operation if it is division or multiplication in word problem for most problems	0.53	**0.89**
Q6.2. The student is able to provide a solution for most mathematical word problems	0.52	**0.89**
Q6.3. The student did not use any drawing strategies to find the solution	0.48	**0.89**
2. ADHD inattention behaviour		
Q8.1. The student is missing details	0.60	**0.88**
Q8.2. The student's work is inaccurate to some extent	0.60	**0.88**
Q8.3. The student is having difficulty remaining focused on tasks	0.62	**0.88**
Q8.4. The student's mind seems elsewhere	0.52	**0.89**
Q8.5. The student is easily distracted	0.62	**0.88**
Q8.6. The student is having difficulties organising the task, for example deciding what to do, what to draw, and how to organise the drawing and the ideas	0.67	**0.88**
Q8.7. The student avoids engagement in tasks	0.66	**0.88**
Q8.8. The student forgets daily activities	0.47	**0.89**
3. ADHD hyperactivity/impulsivity behaviour		
Q9.1. The student taps his/her hands or feet	0.01	**0.90**
Q9.2. The student moves in the seat	0.56	**0.88**
Q9.3. The student often leaves the seat, does not remain seated	0.70	**0.88**
Q9.4. The student runs or climbs in inappropriate situations	0.68	**0.88**
Q9.5. The student is uncomfortable being still for an extended time	0.51	**0.89**
Q9.6. The student talks excessively	0.59	**0.88**

Table 2

Item reliability test after the intervention

Survey items	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
1. Solving mathematical word problems		
Q7.1. You have noticed an improvement in student's performance of mathematics in general	0.49	**0.83**
Q7.2. The student can identify the type of operation if it is division or multiplication in word problems for most problems	0.61	**0.83**
Q7.3. The student is able to provide a solution for most mathematical word problems	0.005	**0.85**
Q7.4. The student is using drawing strategies to find the solution	0.22	**0.84**
2. ADHD inattention behaviour		
Q10.1. The student is missing details	0.76	**0.82**
Q10.2. The student's work is inaccurate to some extent	0.76	**0.82**
Q10.3. The student is having difficulties remaining focused on tasks	0.40	**0.83**
Q10.4. The student's mind seems elsewhere	0.24	**0.84**
Q10.5. The student is easily distracted	0.68	**0.82**
Q10.6. The student is having difficulties organising the task, for example deciding what to do, what to draw, and how to organise the drawing and the ideas	0.53	**0.83**
Q10.7. The student avoids engagement in tasks	0.72	**0.82**
Q10.8. The student forgets daily activities	-0.04	**0.85**
3. ADHD hyperactivity/impulsivity behaviour		
Q11.1. The student taps his/her hands or feet	-0.16	**0.86**
Q11.2. The student moves in the seat	0.39	**0.83**
Q11.3. The student often leaves the seat, does not remain seated	0.60	**0.82**
Q11.4. The student runs or climbs in inappropriate situations	0.55	**0.83**
Q11.5. The student is uncomfortable being still for an extended time	0.57	**0.83**
Q11.6. The student talks excessively	0.70	**0.82**