Using peer tutoring and manipulatives to improve mathematics education in elementary schools in Saudi Arabia

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Using peer tutoring and manipulatives to improve mathematics education in elementary schools in Saudi Arabia

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by

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DECLARATION

This thesis is the result of my research and has not been submitted for any other degree in any other university.

ABSTRACT

The aim of this Randomised Controlled Trial (RCT) study was to research, pilot, test and develop mathematical pedagogies to improve attainment in schools in Saudi Arabia. The pedagogies explored included the use of manipulatives and peer learning. The thesis reports an investigation using a factorial design of the effects of incorporating peer and resource-led learning into teacher pedagogies.

It examined the effects of using peer tutoring and manipulatives, both separately and together, on the mathematical education of fourth grade students (aged 10 and 11) in elementary schools in AlAhsa city in Saudi Arabia, with regard to (a) attainment in mathematics, (b) attitudes towards learning mathematics, (c) attitudes towards learning partners and (d) the students' social relationships. Twenty-four classes were randomly chosen and assigned to different groups. One control group of six classes was taught as usual, and six classes were assigned to each of three experimental groups: that is, six each to the manipulatives group, the peer tutoring group and the group using peer tutoring and manipulatives together. Each experimental group undertook a 12-week programme in the fractions and decimals sections of the fourth grade elementary school mathematics curriculum. The research methods and materials were initially developed during a pilot study involving 8 classes of fourth grade students (aged 10 and 11) in elementary schools in AlAhsa city.

The results of this RCT suggested that the use of peer tutoring and manipulatives, separately and together, significantly affected the mathematical education of those students regarding their attainment, attitudes towards learning mathematics, attitudes towards their learning partners and social relationships. The results also showed that the improvement in the students' social relationships predicted their attainment scores.

Suggestions for further research into the effects of using peer tutoring and manipulatives, both separately and together, on mathematical education in elementary schools, are also made.

DEDICATION

This work is dedicated to the soul of my dear father who has not seen the fruit of his support and effort.

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1 CHAPTER ONE: INTRODUCTION

The aim of this study is to develop, pilot, test and research mathematics pedagogies to improve attainment in schools in Saudi Arabia. The pedagogies explored include the use of manipulatives (concrete materials to aid mathematical thinking) and peer learning. The thesis reports investigations using a factor design to explore the effects of incorporating resource-led and peer learning into teacher pedagogies.

This chapter is an introduction to the study and will be structured as follows. It will start by giving an account of the background and context of the study in Section 1.1. The motivation for the study will be presented in Section 1.2. The problems of the study will be discussed in Section 1.3, followed by the purpose of the study in Section 1.4. Section 1.5 will present the main objectives of the study and the study hypotheses will be given in Section 1.6. An overview of the study will be presented in Section 1.7, while the study's significance will be explored in Section 1.8. Section 1.9 will conclude the chapter by giving definitions of the key words used in this study.

1.1 Background and context of the study

People live and students learn in a social context. Communication is vital in this environment, and this allows mediation to promote learning and understanding (Vygotsky, 1987).

Teachers are advised to use a social learning methodology that helps their students to develop learning and social skills (Cooper, 1990; Johnson, Johnson, & Holubec, 1998; Joyce, Showers, & Rolheiser-Bennett, 1987; Marzano, Gaddy, & Dean, 2000; Millis, 1995; Slavin, 1991; Stahl & VanSickle, 1992; Philips & Soltis, 2004; Brophy, 2002). Education advisors in developed countries have found that cooperative learning plays an important role in developing educational work by improving teachers' and students' academic and social skills. In a meta-analysis of randomised controlled trials (RCTs) by Cook, Scruggs, Mastropieri, and Casto (1985), 19 studies yielded 74 effect sizes, and the study indicated that the tutoring programmes in general had a positive effect on students. According to Roseth, Johnson and Johnson (2009), in their meta-analysis involving 17,000 students in 148 studies, there were positive effect sizes in overall academic achievements (ES=0.46) and the quality of their social relationships (ES=0.48), for students involved in cooperative learning as opposed to isolated, individualistic learning. In a meta-analysis that included 148 studies from 11 countries by Roseth, Fang, Johnson and Johnson (2006), academic achievement was strongly related to interpersonal perception for middle-grade students. Ginsburg-Block, Rohrbeck and Fantuzzo (2006), in a meta-analysis involving 36 studies of peer learning in elementary schools found a positive correlation between social and self-concept outcomes and academic outcomes (Pearson's $r=0.50$, $n=20$, $p<0.01$).

In the twentieth century, researchers considered the importance and application of cooperative learning. These studies also examined the effect of training teachers to use cooperative learning to enhance students' education. Cooperative learning forms maximise essential communication skills and scientific thinking skills. They help both teachers and students by building the social environment, so students can construct the thinking and understanding which enable them to interact with their teachers and other students (Chin & Brown, 2000; Jones & Carter, 1998; Meyer & Woodruff, 1997; Millis, 1995; Resnick & Klopfer, 1989; Wood, 1992).

Johnson and Johnson (1994) suggested that in cooperative learning, students learn together in small groups, ideally comprising from two to five members, in order to achieve common goals. Positive social interdependence between both the individual and the group should be structured in successful cooperative learning. In other words, both the individuals and the group must all do their part in the learning process, and every individual succeeds when the all the group members succeed. Johnson and Johnson (1994) reported that students' attainments, performance, mental health and self-esteem were improved in comparison with students with whom individual learning methodologies were used.

According to Johnson and Johnson (1994), there are five main elements that must be incorporated into the learning process in order to achieve effective group learning: potential for improvement in the students' achievements, their social cognitive skills, their personal cognitive skills (such as problem solving), their decision-making skills and their planning skills.

Topping (2005) defined peer learning as the "acquisition of knowledge and skills through active help and support among status equals or matched companions" (p.631) and explained the various components of peer learning. The old-fashioned peer helper was similar to the modern-day support teacher or teaching assistant; thus, the teacher-in-charge transfers knowledge to the peer helper, who conveys it to students. Peer learning has good instructions that can be followed successfully by school teachers, parents and any others who may use it (Ainscow, 1991).

There is debate over the best framework for peer learning (Duran, 2010). Therefore, researchers have undertaken a number of studies on peer learning, and suggested a number of frameworks for the best way to manage it. Two frameworks stand out from the others: peer tutoring and cooperative learning.

Peer tutoring is a form of cooperative learning. It normally involves work in a dyad. One student takes the role of tutor, whose job is to monitor, evaluate, assess and guide the work of their peer. The other student in the dyad takes the role of tutee, who is normally the one who actually undertakes the work, which is monitored by the tutor. Peer tutoring usually has highly structured protocols established for peer interaction. It can also be used to structure the learning of reading and mathematics (Duran, 2010).

Topping and Bamford (1998) designed resources, published in their ‘Paired Maths Handbook’, to encourage parent tutoring at home in mathematics. The book was designed to be used in both peer tutoring and parent tutoring.

Cross-age tutoring is another of the tutoring programmes; this involves older students as tutors helping younger students as tutees in the learning subject. There are significant advantages for all involved in these programmes, i.e., the tutor, the tutee, the teacher and the school learning environment as a whole (Rosner, 1996).

Same-age and cross-age tutoring are the two most common forms of tutoring programmes. Although cross-age tutoring is more commonly used in schools, same-age tutoring can also be effective; a number of research studies indicated that the most important aspect is not the age difference, but the skills difference between tutor and tutee (Duran, 2010). In same-age peer tutoring, the ‘student’ and ‘teacher’ in a pair will exchange roles, so that each plays both parts in the exercise (Duran, 2010).

Both students and teachers can benefit from using peer tutoring. According to Olmscheid (1999), “The list of benefits that students receive from peer tutoring is quite extensive” (p. 3). These benefits will be addressed in more detail later in this discussion, and more broadly in the literature review in Chapter Two.

Together with peer tutoring, when manipulatives are used in conjunction with a social learning method they appear to have a positive effect on students’ learning of mathematics, while simultaneously helping them to improve their communication skills (Barone and Taylor, 1996; NCTM, 2000; Pickett, 2011).

According to Moyer (2001),

> Manipulative materials are objects designed to represent explicitly and concretely, mathematical ideas that are abstract. They have both visual and tactile appeal and can be manipulated by learners through hands-on experiences. Manufacturers advertise manipulatives as materials that will make the teaching and learning of mathematics "fun" and promote their products as catalysts for engaging students in mathematical learning (p. 176).

Using manipulatives when teaching mathematics can be helpful (NCTM, 2000). Manipulatives can help teachers build a social environment of which students can take advantage, help students with verbal thinking and improve their social skills and confidence. These benefits will be examined in more detail later in this discussion, and more broadly in the literature review chapter.

However, the effective use of manipulatives requires reflective teachers who can make mathematical ideas more understandable and meaningful (Clements, 2000; Stein & Bovalino, 2001).

Manipulatives can be used by mathematics teachers simply to reform their teaching without reflecting on their purposes and the way they should be presented to the students, or making clear their link with the subject. Some teachers might use inappropriate manipulatives, or represent them wrongly to their students. This can negatively affect students' learning. These teachers should reflect on the purpose of manipulatives, and the way in which they are used (Clements, 2000; Stein & Bovalino, 2001; Moscardini, 2009).

Four elements were identified through which to assess the effects of using peer tutoring and manipulatives, both separately and together, on students' learning of mathematics: student attainments, their attitudes towards mathematics, their attitudes towards their learning partners and improvements in their social relationships. The role of teachers is important in terms of achieving the greatest benefit from using manipulatives and teachers should be constantly aware of the way in which they are using them (Clements, 2000; Stein & Bovalino, 2001; Moscardini, 2009).

Moscardini (2009) suggested that although students with difficulties in understanding may achieve meaningful learning when their teachers use hands-on materials, teachers should be more aware of the purpose of using these materials, and particularly of the way in which this affects their teaching. It is a challenge for teachers to have a greater awareness of their students' mathematical thinking skills, in order to develop suitable teaching environments.

When using manipulatives, teachers should follow the recommendations drawn from theories of learning in order to help students gain the greatest advantage from their use. Learners must be actively involved in their learning in order to construct their knowledge and obtain more information effectively, rather than merely constructing their knowledge-base through others; learners build their own meanings (Poplin, 1988).

1.2 Motivation for the study

After I was awarded my Bachelor's degree in mathematics from the AlAhsa teaching college, I became a mathematics teacher in an elementary school. At the teaching college, we learned about learning theories and the significance of involving the students in the learning. However, in Saudi Arabia, the traditional teaching and learning method is for the students to be passive recipients of the information imparted by the teacher. There is no interactivity in the classroom, with no communication between teacher and students, and no discussion or debate. Hence, when I started teaching mathematics I found myself in the position of giving lectures as my students simply sat in their chairs and I did everything. I did not find any supporting materials and no one encouraged me to use any. After I asked about such material, the school principal guided me to the school storage room where I found a number of manipulatives covered in dust, which appeared to have been unused for many years. At this point, I took them and dusted them to get them ready for use. I searched for a manual that could help in using them. The other teachers at the school were surprised by the manipulatives and they seemed not to have seen them before; some of them asked me about them, how they could be used and for what purpose. I found the manipulatives very helpful and I saw my students becoming more interested in learning, which encouraged me to read more about teaching methods that could enhance my teaching further. I tried a number of methods including group work learning and found these to be very helpful. At that point I became more interested in using manipulatives.

In 2008, I had the opportunity to do my Master's degree in Education in the UK and wrote my Master's dissertation on the issues of using manipulatives in teaching mathematics in Saudi Arabia from teachers' perspectives. The result of the dissertation suggested that there was a lack of training for mathematics teachers in the use of effective teaching methods. I then obtained a scholarship to do my current PhD study and with further reading, I became more interested by the use of peer tutoring in learning mathematics. From my reading, I became aware that while a number of studies recommended the use of materials such as manipulatives and peer tutoring together, there was no study which examined the use of these together, or which examined them separately and then compared the two. Therefore, I saw a research gap which this present thesis attempts to narrow.

A large body of literature, much of which will be reviewed in Chapters One and Two, has provided evidence to suggest that the use of manipulatives and peer tutoring can be effective methods of learning mathematics. Although the effect of using both of these methods together has not been investigated, it is logical to assume that they can complement each other and increase the value of learning mediation.

1.3 Problems of the study

In the world of learning there are always issues that must be solved. Investigating these is best done by researchers, who need to explore, understand and find solutions for such issues.

Many students have difficulties in learning mathematics. According to Haylock and Thangata (2007), there are five categories into which the learning of mathematics can be divided. The first category is utilitarian, in which students use mathematics to deal with the problems of everyday life. Numeracy is the most useful mathematical element here. The second category is application, whereby students are helped to deal with issues they might face in other subjects, such as physics and chemistry, and develop their knowledge and skills to the necessary level for understanding mathematics. The third category relates to developmental thinking; that is, students develop their thinking skills, very commonly through problem-solving, for which they should also aim to think in abstract terms. The fourth category is aesthetic. Here, the aim is to guide students to appreciate the beauty of mathematics, and to enjoy learning it as much as other subjects. The fifth category is epistemological. Mathematics can be described as one of the most important fields of education for any society that calls itself civilised, related as it is to many of the sciences.

According to Liebeck (1984), there are six questions on the why and how of learning mathematics. The first is, ‘Why teach mathematics?’ It is well known that mathematics as a science is a powerful and important tool at every level of our daily lives. The second is, ‘Why do people enjoy mathematics?’ Although mathematics may seem to be boring for some people, a great number of others enjoy it as much as learning about, or listening to, music and other arts. The third question is, 'How can mathematics appeal to one aesthetically, in a way similar to music or art?' In the same way that people enjoy music or art in different ways, they can enjoy the different elements of mathematics. Some enjoy algebra, others enjoy other branches of mathematics. The fourth question is, 'Mathematics is often called an abstract subject. What is meant by this?' It is clear that most mathematical ideas are hard to explain unless they are explained physically as a first step. Many people, particularly very young children for example, cannot understand what '3' means, or 'the threeness of three' as it is sometimes described, without repeatedly being shown and able to handle one, two and three objects. The fifth question is, 'How does the brain cope with this hierarchy? When one sees the symbol '143', one does not imagine one hundred and forty-three objects set out before one. Has one then lost contact with the real world?' The answer is no. The reality in such an example must be understood through the system of notation. One should imagine three singles, four groups of ten and one group of one hundred. Finally, 'How does a child develop abstract thought?' The child needs four steps in order to do this, namely experience with physical objects; spoken language that describes that experience; pictures that represent the experience and written symbols that generalise the experience.

In Saudi Arabia, students are in need of effective learning methodologies that will improve their learning, particularly in mathematics. Saudi students in the 4th and 8th grades (aged 10-11 and 13-14 years old respectively) scored below the international average in the Trends in International Mathematics and Science Study (TIMSS) in both 2007 and 2011. For example, out of 52 countries participating in the 2011 maths test, the 4th grade students ranked 44th with an average score of 410; while the 8th grade students ranked 37th out of 45 countries with an average score of 394. Less than half the 13-year-old Saudi students achieved the lowest benchmark score, compared with 99% in South Korea and 88% in England. Just under 1% of Saudi students scored the advanced level, whereas 47% of South Korean students and 8% of students in England did so (Provasnik et al., 2012).

This indicates that students in Saudi Arabia are in need of significant efforts to improve their level of understanding of mathematics in order to reach the international average.

Although the TIMSS reports in 2003, 2007 and 2011 showed that the Saudi students scored lower than the international average, and Saudi Arabia was at the bottom of the list of the countries participating in the test research, as far as this researcher is aware, to date there has been no study investigating the reasons for this. However, the Saudi government has realised the importance of developing education in the country and therefore they developed a number of projects to address this issue.

In 2007, the Saudi government established The King Abdullah Project for the Development of Public Education, with a budget of US$3.1 billion (Asharq Al-Awsat, 2007). According to its website, the aim of the project is to overcome the challenges faced by state education in Saudi. The main challenges have resulted from the need for new skills demanded by the development of information and communication technologies and globalisation. This has encouraged the Saudi government to start thinking about the need to develop the education system, and the Ministry of Education has reported on the need to improve the students' achievement levels in mathematics and science. The project established a new vision for a new educational system including changes for students, schools, districts, and Ministry of Education rules.

According to the project website,

> the new vision for the learners, schools, Districts and the Ministry of Education requires a major transformation in the overall institutional arrangement underlying the delivery of education services in the Kingdom, and an integrated set of actions at the three levels of the system to align policies and regulations, and to build the capability of the change agents to lead the education system (p. 7).

The newspaper Asharq Al-Awsat (2007) published the project committee chairman's statement to the effect that it is important to take into account experiences of other countries and include these in the processes of developing and improving education in Saudi Arabia. Saudi education officers should visit successful countries, and gain from their knowledge and perceptions in order to benefit from their success. To that end, a number of visits were organised to the United States, United Kingdom, Ireland, Austria, Switzerland, Canada, France, New Zealand, Malaysia, Singapore, Korea, China and Japan.

Although the project shows great promise and the expected outcomes are likely to be achieved, a number of issues must be discussed in relation to it. It is argued that the project is building on studies conducted in other countries, but there is a need to examine every change in policy with relation to national rather than international studies. Although the findings and recommendations drawn from research studies conducted in other countries can suggest ideas and strategies that can help to develop educational policy and practice in those countries, it is important to examine these ideas in Saudi Arabia to ensure that they suit the Saudi context. What works in other contexts does not guarantee success in the Saudi context. The project budget is of necessity very high, allowing funding to support research studies at policy-making level.

This research study introduces a research method into the Saudi context that, it is proposed, can work there, and provide highly reliable results that should be considered for the introduction of new practice in education. The King Abdullah project website, however, has not yet reported any research outcomes or results, despite its efforts. No improvement in students' learning has been discussed on the website. It is even suggested that the King Abdullah project has used the methods introduced by this study to introduce, scrutinise and evaluate new educational initiatives.

This researcher worked as a mathematics teacher of elementary level students (aged from 10 to 14 years old) in Saud Arabia for one year and as a graduate teaching assistant in AlAhsa, where he taught at AlAhsa Teacher Training College in the Curriculum and Teaching Methodology department, which required working closely with schools and children. From his own classroom experiences he has found it challenging to identify methods that teachers can use to facilitate each student's learning. Although teachers work hard to motivate their students, it is very difficult to try to meet the needs of every student simultaneously, and time constraints do not allow teachers to spend time individually with each student every single day. However, there are teaching methodologies and resources that can help both teachers and students to maximise the value of their time in school, in order to increase the value of students' learning.

The teacher is one of the keys to success in the learning of mathematics. Children learn through involvement in practical activities that they undertake themselves. The lack of both the undertaking itself, and the supervision of such activities where they do exist, can be harmful to their understanding of mathematics.

Alghamdi and Alsalouli (2012), in a qualitative study, conducted in-depth interviews with ten science teachers (six women and four men) with various academic backgrounds, and teaching experience ranging from 2 to 28 years. They stated that a dearth of Saudi teachers' voices in science education literature encouraged them to undertake their study. They found the science teachers' development and training provided by the Ministry of Education in Saudi Arabia was inadequate to help teachers to understand the new curricula and the use of new teaching methods. Although 80% of the participants in Alghamdi and Alsalouli's (2012) study believe that the training they received at university before they started teaching in school was useful, they find it challenging to engage their students in their learning now they are serving teachers. The study found that there are two factors that discourage teachers from reforming teaching: the limitation of the resources, and the lack of professional development offered by the Ministry of Education in Saudi Arabia.

Although Alghamdi and Alsalouli (2012) focused on science teachers, its results can also be applied to mathematics teachers. The mathematics teachers participating in this researcher's study agreed on several occasions on the limitation of resources and the lack of professional development provided by the Ministry of Education. This concurs with the researcher's own experience and the statements of mathematics teachers in informal discussions with the researcher concerning the problems they have when teaching mathematics.

Thyer and Maggs (1991) stressed that the role of teachers is significant in teaching mathematics. As children's ability to discover mathematics solely through their environment is limited, they develop their understanding of concept, from practice to theory, using language, which makes the teachers' role very important.

Among of the most significant difficulties in teaching mathematics is the challenge of using teaching methodologies and resources effectively, and the fact that teachers may have insufficient experience with such methodologies and activities to help them improve the value of what they are teaching.

Price (2006) asserts that teachers are responsible for establishing a suitable environment for creative lessons in the classroom, necessitating skills which they are developing increasingly.

Although teachers need to be knowledgeable about what they teach, high quality teaching skills can be more important than knowledge. Students should be involved in practical activities and given opportunities to explain their thinking about what they are doing. This might help teachers to reflect on the students' knowledge (Philips & Soltis, 2004; Kimball & Heron, 1988; Ormrod, 2004). Making an active learning environment for students needs reflective teachers who can create opportunities for students to engage with their learning and share their knowledge with each other. This is no easy task for teachers.

McKinney, Chappell, Berry, and Hickman (2009) stress that teaching methods are central to how much the student understands and retains when learning mathematics. However, teachers still seem to use the traditional lecture and directed instruction more than methods that focus on involving and engaging students in the learning process when they teach mathematics.

McKinney et al. (2009) show the importance of the teachers' role in teaching mathematics and the difficulties that teachers face in choosing and applying effective introduction and scrutiny of new practice in education methods. They also describe the difficulties that teachers face when they use such methods.

Bayazit and Gray (2004) found that differences in the quality of teaching led to different learning outcomes. They concluded that teachers should involve their students in real life situations to develop a conceptual understanding of the topics under discussion, and that the best way to ensure that students are doing so is to use appropriate learning methods that actively involving the students in the learning process.

Bayazit and Gray's (2004) view stresses that teachers' roles are very significant and not easy; and they concur with Philips and Soltis (2004), Kimball and Heron (1988), Ormrod (2004), and McKinney et al. (2009) about the importance of involving and engaging students' in the learning process, agreeing that choosing and applying effective teaching methods is one of the most challenging aspects of teaching mathematics.

In Saudi Arabia, the established behavioural rules and principles were the preferred methods in education. According to Alhamid, Zeyada, Alotaibi and Motwalli (2009), the teachers dominated both the students and the lesson, and therefore the students were thought of merely as recipients of imparted knowledge.

The idea explored by Alhamid et al. (2009) emphasises the difficulties Saudi teachers experience in engaging their students with their learning when thinking of their students in the traditional way. A shift from this way of thinking is required to comply with modern learning methods that stress the importance of the role of students in the learning process. The paucity of literature suggesting effective ways of helping teachers to engage their students in learning mathematics in Saudi education is one of the greatest difficulties facing a Saudi mathematics teacher.

It is important to conduct research that focuses on these issues and suggests solutions to them, and guidance on the best methods for increasing the quality of learning should be established. This viewpoint has encouraged many institutions and educational bodies worldwide to establish research centres in teaching and learning mathematics and other subjects.

The Centre for Evaluation and Monitoring (CEM) at Durham University and the Institute for Effective Education at York University (IEE), both of which are in

England, The National Council of Teachers of Mathematics (NCTM) in the USA and the Centre for Effective Education at Queen’s University in Belfast are examples of centres and institutions that were established precisely because of the perceived importance of conducting research into learning and teaching mathematics (CEM, 2014; IEE, 2014; NCTM, 2014).

One of the most important aims of the CEM is to conduct Evidence-Based Education (EBE) and to evaluate carefully the educational interventions and policies before they are in use. At the very least, such interventions and policies should initially be adopted experimentally to evaluate their impact (CEM, 2014). This aim stresses the significance of conducting research to develop and evaluate educational interventions. The experimental study approach can be the best way to examine interventions that are in use in schools. The IEE at York University was established on the premise that students deserve to be given opportunities to succeed in their learning. The aim if the IEE is to enhance education by researching into “what works” in education. The conviction of the importance of solving through educational research issues that might be faced in teaching and learning was one of the reasons for establishing the Institute (IEE, 2014).

The Centre for Effective Education at Queen’s University in Belfast state their mission as

> Ensuring that educational programmes and interventions are as effective as possible in helping to improve the lives of children and young people, especially from disadvantaged backgrounds. This commitment to promoting effective education is reflected in our emphasis on being: children's rights-based; outcomes-focused and evidence-informed (CEE, 2014, para. 1).

Like the CEM and IEE, the CEE supports research studies through to their completion, as well as the evaluation of educational interventions.

The NCTM vision states

> The National Council of Teachers of Mathematics is the global leader and foremost authority in mathematics education, ensuring that all students have access to the highest quality mathematics teaching and learning. We envision a world where everyone is enthused about mathematics, sees the value and beauty of mathematics, and is empowered by the opportunities mathematics affords (NCTM, 2014. para. 3).

The NCTM includes research activities in all the Council's activities to ensure that issues are resolved with the highest quality evidence.

The efforts of all these bodies - the NCTM, IEE, CEM and CEE - stress the significant role educational research can play in the improvement of teaching and learning in schools.

This can help teaching organisations improve the value of their teaching, and, in turn, help to improve other sciences and therefore impact on modern-day life. Improving the learning of mathematics has been the central goal of educators worldwide, and, to this end, many learning institutions have been established and there have been numerous research studies, learning methodologies, books and educational projects. Those cited above are but a few examples of the efforts made to enhance teaching and learning worldwide.

Saudi education is in need of research that discusses and suggests solutions to the issues relating both to learning in general and to learning mathematics in particular. It is also important to establish guidance on which methods are best for learning mathematics.

1.3.1 Theoretical background

The teaching of mathematics has been affected by educational theories and psychological concepts. The works of Jean Piaget and Lev Vygotsky, two famous psychologists whose theories influenced the world of learning, have played fundamental roles in the development of constructivist theories. Although both considered that classrooms must be constructivist environments, there are differences in the way each believed that constructivism should be used in the classroom.

According to Piaget (1896-1980), the psychological development of young children has four sequential stages, about which teachers should know and through which they should guide their students. Vygotsky (1896-1934), on the other hand, describes learning and development as collaborative activities in which children develop their cognitive skills through mediation and interaction between tutor and tutee.

The zone of proximal development (ZPD) has been defined as “the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers” (Vygotsky, 1978, p.86).

Vygotsky (1978) described interaction between students as an effective method with which to develop their skills and strategies. Teachers use cooperative learning forms, where the tutor mediates the tutee’s learning within the zone of proximal development.

Vygotsky believed that when a student is solving a learning problem in the ZPD, providing suitable help will enhance the students’ ability to succeed in the task. In other words, the tutee will achieve better quality learning when it is mediated by the tutor than when he or she learns alone.

A number of theories, learning methodologies and learning tools have been designed and based on the principles of both Piaget and Vygotsky, and these are examined in the literature review in Chapter Two.

Culture plays an essential role in the learning process, since learners use tools that have been developed in sociocultural contexts. These tools help learners achieve higher levels of thinking skills (Vygotsky, 1987) and, as Vygotsky suggests, the active roles in the learning process are important as they bridge the gap between 'what is known' and 'what can be known'. Brophy (2002) asserts that it is essential to give students opportunities to raise questions during lessons, and to help them search for deeper understanding, as opposed to simply being receptive, concluding that classroom environments should be active and encourage discussion throughout the learning process. Thurston, Duran, Cunningham, Blanch, and Topping (2009) report that the use of cooperative learning affected students' performance for the better, noting positive interaction and discourse reaction throughout the study. Cooperative learning reduces individuality and individual competitive behaviours, encouraging students instead to cooperate in group activities as they learn (Cooper, 1990; Johnson, Johnson & Smith, 1998; Joyce, Murphy, Showers, & Murphy, 1987; Marzano et al., 2000; Millis, 1995; Slavin, 1991; Stahl & VanSickle, 1992).

Frobisher (1999) identified a number of manipulatives that can be used to introduce and explain mathematical ideas and concepts. These manipulatives can help teachers build a social environment, of which students can take advantage and in which they can share their knowledge and experiences with each other. Manipulatives assist students with verbal thinking, helping them to discuss mathematical ideas easily and effectively, improving their abilities to translate real-life problems into mathematical problems, providing them with opportunities to improve their social skills and increasing their confidence in, for example, making presentations and expressing ideas (Hartshorn & Boren, 1990). Clements (2000) stressed that the effective use of manipulatives requires reflective teachers who can make mathematical ideas more understandable and meaningful. Therefore, mathematics teachers should be aware of the purpose of using manipulatives as they relate to their stances on particular learning theories, and consider carefully the way in which they are actually using them. Stein and Bovalino (2001) support this view, emphasising that good and effective learning using manipulatives cannot be guaranteed unless encouraged by reflective teachers with the ability to use them effectively.

It is essential for teachers who use manipulatives to identify when, why, and how to use them effectively to enhance their students' learning and improve the quality of classroom activities. It is also important for teachers to create opportunities for students to observe and explore these manipulatives.

Vygotsky (1962) suggested that students, who initially construct their own beliefs and understanding from their own experiences, could be guided to move that thinking into a more scientific, conceptual realm by adults who mediate their learning and lead them to deeper, independent understanding.

The literature leads to the conclusion that using a social learning methodology that allows students to learn collaboratively is essential for the learning of mathematics and can enhance the students' communication skills that mediate their learning. An increase in communication and conversation relating to the subject being learned has a very positive effect on students' learning.

It seems that combining of the use of manipulatives with a social learning methodology can further enhance the interaction between the students, and can lead their communication to focus on the learning of mathematics, structure the learning process more and enhance the mediation.

1.3.2 Combining the use of peer tutoring and manipulatives in learning mathematics

Vygotsky explained that learning is a social process, in which communication, and particularly talking, mediates the learning is significant in the learning process. Therefore, the design of an effective learning environment should encourage and improve students' communication and conversation associated with the subjects being learned, and mediate learning. The more that communication is related in this way, the greater will be the positive effect on students' learning will be positively affected. "Communication is an essential part of mathematics and mathematics education" (NCTM, 2000, p. 60).

Although teachers use manipulatives as cognitive tools, and while they appear to improve students' learning of mathematics, such use cannot guarantee success in the absence of an effective learning methodology that improves the value of the interaction and communication between students which increases the value of their learning mediation. The use of manipulatives was also reported to increase students' communications, which in turn enhanced their learning of mathematics (NCTM, 2000; Shaw, 2002). The use of manipulatives appears to increases this value by encouraging the learning discussion to be more focused on the learning subject; however they should preferably be used to share learning in an active learning situation. This is one of the benefits of such use that will be discussed later in this introduction, and more deeply in the literature review in Chapter Two.

Peer tutoring, one of the cooperative learning strategies developed in the light of Vygotsky's description of learning as a social process, has a long and successful history as an effective method of learning, with communications and conversations related to the subjects being learned more likely to improve when peer tutoring is used. Furthermore, the use of peer tutoring positively develops students' communication and social skills, thus improving the value of the learning mediation.

According to Barley et al. (2002), successful peer tutoring in learning mathematics usually includes three main elements, namely training the students to be prepared to act as tutors and tutees so they understand the process of peer tutoring, involving well-structured activities in which the students can interact socially and using materials such as manipulatives. Students should act sometimes as tutor and sometimes as tutee, thereby, and very importantly, training them to understand the process of the two roles. Well-structured activities are important in any successful peer tutoring; therefore, teachers should plan their lessons and be prepared with the necessary materials for the lesson. Given the importance of involving materials such as manipulatives in increasing the advantages of peer tutoring in mathematics, it is suggested that teachers should provide these manipulatives when they use peer tutoring.

Although the use of materials with peer tutoring in learning mathematics was suggested in the literature, some authors did not make clear either which kind of materials teachers should present to their students or the way in which these materials should be used. Few studies mentioned manipulatives as materials that should be used together with peer tutoring in learning mathematics.

Barone and Taylor (1996), in a field study at Fulton Elementary School in Aurora including 440 mixed ethnicity students, suggested that teachers should be required to prepare manipulatives and train their students to teach each other when they use peer tutoring. The results of this study suggested that the students' self-esteem, sense of responsibility, skills, motivation, academic attainment, awareness of needs of others and appreciation of teachers all improved significantly when they learned mathematics using peer tutoring and manipulatives together, and that teachers were positively affected by that improvement.

An unpublished action research study by Pickett (2011) involving one fourth-grade mixed ethnicity classroom of twenty students (ten male and ten female) in Hunter Street Elementary schools in York, South Carolina, examined the effect of using peer tutoring on the students' achievement and suggested adding the use of manipulatives to the peer tutoring. Students' achievements, attitudes towards mathematics and attitudes towards their learning partners showed statistically significant improvement after the intervention.

Thus, the research studies have clearly shown a relationship between the increase in communication between the students and the improvement in their learning of mathematics using peer tutoring. Therefore, it is suggested that using manipulatives with a social learning strategy maximises the benefits of the use of each. As mentioned in the literature, the use of manipulatives cannot guarantee that students will benefit by using them, unless they are used in an appropriate way.

In conclusion, it is suggested that manipulatives should be used in a social learning strategy and that peer tutoring in learning mathematics should involve the use of manipulatives. While using both manipulatives and peer tutoring on their own was reported to enhance the students' communications, and therefore their learning, the literature on using a combination of peer tutoring with manipulatives in learning mathematics is limited.

The studies examining the use of peer tutoring suggested the use of manipulatives, and made suggestions as to how they should be used in a social way. However, this is the first study to examine both the effects and the results of using peer tutoring and manipulatives, both separately and together. Furthermore, the literature does not explain which is of greater value - the use of peer tutoring or the use of manipulatives; and whether combining them positively or negatively affects students' learning of mathematics.

As the use of manipulatives and peer tutoring individually affects the students' communication and social skills, and enhances the learning mediation by directing the focus of the students' interaction on to the learning subject, it is worth examining the effect of their combined use in learning mathematics, as together they may help both improve the value of the communications and conversations of the students and guide the conversations towards topics related to the subject being learned. It is also possible that peer tutoring and manipulatives reveal reciprocal benefits when used together.

As stated previously, Saudi mathematics teachers are in need of an effective teaching method to help them follow the educational strategies used in more developed countries. This research examines peer tutoring and manipulatives, used separately and together, as effective teaching methods in a Saudi context, to assess whether they could profitably be offered to the education community in Saudi Arabia.

1.3.3 Benefits of using manipulatives and peer tutoring in learning mathematics

Manipulatives are helpful and have a number of benefits (NCTM, 2000). First, they help present abstract concepts on an abstract level (Berk, 1999).

They can also establish a solid foundation of those concepts and help students to understand them thoroughly and effectively. Krontiris-Litowitz (2003), in an experimental study involving modelling clay and beads as manipulatives, found improvements in conceptual understanding, dismantling misconceptions and critical thinking. Although there were students who were inactive during the teaching activity, they showed improvement during quizzes.

Manipulatives increase students' interest in learning mathematics and their excitement about mathematical concepts. Rust (1999) conducted an experimental study to establish which of the two teaching methods, using manipulatives or teaching from the textbook, best helps students to understand mathematical concepts. Although the students who learned through the textbook did better than those who learned through manipulatives, students' enjoyment increased more when they learned through manipulatives and hands-on learning than with the textbook.

The use of manipulatives also improved the students' academic achievement. For example, an experimental study by Moch (2001) which examined the effect of using manipulatives on 16 fifth grade students found that one-third were identified as exceptional after the use of manipulatives. The results of the Moch study showed that the students' post-test results increased from 49% to 59% and all areas improved compared to pre-test scores.

Verbal communication is axiomatic when using manipulatives in learning mathematics (Moch, 2001), and Cramer and Karnowski (1995) found a connection between the use of manipulatives and an improvement in students' communication.

Kosko and Wilkins (2010) conducted an empirical study on fifth grade students (aged 10 and 11 years old) in the USA. The study used data taken from the Early Childhood Longitudinal Study which involved 11,820 fifth grade students around the USA, a subsample of which (N=4,922) was included in this study. Mathematics teachers who participated in that study completed a questionnaire for every individual student relating to classroom practice and information. The study suggested that a statistically positive relationship exists between manipulative use and communication in mathematics. The correlations were observed between manipulative use and both writing ($p=.32$) and discussion ($p=.32$).

Cramer and Karnowski (1995) described the manipulatives as interacting between two types of symbol, such as real-life situations, pictures, verbal and written symbols. However, they did not provide or support evidence of any relationship.

The link between manipulatives and communication was discussed in the methods of other studies. Moyer (2001) conducted a study on teachers who use manipulatives in teaching mathematics. The discussion between students was a part of the use of manipulatives. Moyer's study aimed to examine the reasons for, and the ways of, using manipulatives by middle school teachers. One of the studies focused on classroom discussion; students' interactions, leading to conversations, were highlighted as among the most important factors in the way students' used manipulatives, and improved interpersonal communication as one of the most positive effects. The study showed that students' communication was one of the positive effects of using manipulatives; however, the study also showed that although teachers directed the use of manipulatives and conversations, they did not appear to put as much emphasis on conversations as was suggested by the use of manipulatives.

The Moch study (2001) discussed earlier, on the effects of using manipulatives on improving skills in the different mathematics subjects, stressed that the students' test scores improved by ten percent, although the manipulatives were used for just 18 hours in seven weeks. The study mentioned that teachers used several teaching strategies that seemed to be effective, including discussions and discourses. However, the study did not mention the amount of discourse included when manipulatives were used.

Stein and Bovalino (2001) included discourse between the students as one type of necessary activity when using manipulatives, another being writing. The aim of the

Stein and Bovalino article was to present examples of effective ways of using manipulatives.

Both *Mathematics Assessment: A Practical Handbook for Grades 6-8* (NCTM, 2000) and *Literacy Strategies for Improving Mathematics Instruction* (Kenney, 2005) linked the use of manipulatives with communication.

A high number of studies indicate that both students and teachers can benefit in four main but different categories by using peer tutoring: students' attainment (Johnson & Johnson, 1994; Topping, 2005; Harris & Sherman, 1973; Pigott, Fantuzzo, & Clement, 1986; Kamps, Barbetta, Leonard, & Delquadri, 1994; Vincent & Ley, 1999; Tymms et al., 2011); social relationships (Johnson & Johnson, 1994; Roseth et al., 2006; Topping, 2005; Fitz-Gibbon, 1988; Tolmie, 2010; Johnson, Johnson, Scott & Ramole, 1985); attitudes to learning (Topping, 2005) and benefits enjoyed by teachers due to an increase in student engagement with learning (Johnson & Johnson, 1994; Philips & Soltis, 2004; Brophy, 2002).

These effects will be discussed more broadly in the literature review in Chapter Two.

1.3.4 The use of manipulatives and peer tutoring in learning mathematics in elementary schools in Saudi Arabia

In the researcher's personal experience as a mathematics teacher in an elementary school (2003-2004), and as a supervisor of students at AlAhsa Teacher Training College (2004-2006), a great number of teachers in Saudi Arabia either do not use manipulatives in their teaching or use them ineffectively.

Teachers rarely use collaborative learning strategies when teaching mathematics to elementary students (aged from 10 to 14 years old). When the researcher held an informal discussion with teachers, some told him that manipulatives might confuse students, while others admitted that they did not know how to use them correctly or offered further reasons relating to class management and the unavailability of manipulatives for not doing so. The same reasons were given when they were asked why they did not use collaborative learning strategies. Both the observational visitations and the formal and informal conversations were undertaken during the pilot study; the main study emphasised the poor use of manipulatives and collaborative learning strategies. This reflects Alhamid et al.'s (2009) observations of teachers in Saudi Arabia which revealed their concentration on behavioural rules and principles in their teaching, their perception of students as recipients of knowledge and their domination of both students and lessons.

The present researcher was unable to find research that considers the use of peer tutoring and manipulatives, either separately or together, in learning mathematics in Saudi Arabia. There is, however, an experimental study by Gubbad (2010), conducted in the city of Makkah in Saudi Arabia, which examined the effect of cooperative learning on the academic achievement and retention of mathematical concepts of 59 sixth grade students (aged 12-13 years old) divided randomly into two groups: a control group (29 students) who were taught mathematical concepts using traditional methods, and an experimental group (30 students) who were taught using the cooperative learning strategy. The results of the study revealed that in the Achievement and Retention test there was a statistically significant difference ($p < 0.05$) between the mean scores of the performance of the experimental and control groups, with higher scores for the experimental groups. The study suggested that maths students in Saudi Arabia needed effective learning methodologies to enhance their learning and that maths teachers needed training in the use of effective teaching methodologies.

Although the Gubbad (2010) study is the only experimental study to have investigated the use of peer learning forms in learning mathematics in Saudi Arabia, there were some limitations in that study. The sample of the study was small (59 students); it examined the use of cooperative learning without manipulatives; it examined only the students' achievements and attitudes towards mathematics, and omitted their social relationships. Furthermore, it was conducted in just one city - Makkah – and so its results cannot be assumed to be relevant to the whole Saudi context. With these limitations in mind, the results of Gubbad's study can highlight the importance of conducting experimental studies in learning mathematics in elementary schools in Saudi Arabia.

There are, however, several books and studies that consider the usefulness of creative methods and manipulatives in teaching mathematics in Saudi Arabia. All agree that teachers should be encouraged to use manipulatives effectively (Abo-Zena, 2003; Obeed, 2004), as what led these authors to write these books and conduct these studies was their observations of the ineffective usage of manipulatives. Abo-Zena (2003) stated that, although the curricula used to teach mathematics had been developed and changed, mathematics teachers still used stultifying and ineffective methods. Encouraging teachers to use effective collaborative learning strategies is one of the major goals of the educational programmes provided by the teachers' colleges responsible for training graduate elementary teachers. However, mathematics teachers at elementary schools do not seem to follow these recommendations.

The avoidance or ineffective use of manipulatives and collaborative learning strategies might occur for different reasons, such as teachers' inexperience in using them, or their limited inclusion in training courses. Swan, Marshall, Mildenhall, White and de Jong (2008) found that the most common reasons preventing the use of manipulatives were:

1. Money: teachers who do not find manipulatives already present in their schools would need to buy them with their own money, which could be costly.
2. Behaviour or classroom management: there are teachers who think that the best way of teaching is to keep the classroom quiet and the students in their seats.
3. Organisation of materials: with the availability of manipulatives in the school, teachers are afraid of issues such as borrowing and returning equipment, or sorting missing pieces.
4. Classroom conditions: the classroom layout and its space might affect the use of manipulatives since teachers might find it inconvenient to change the layout of the classroom due to limited space or difficulty in rearranging the tables.

During informal discussions, mathematics teachers gave similar reasons for not using collaborative learning strategies to those cited by Swan et al. (2008). Teachers always spoke of students' behaviour and classroom management, the difficulties of organising such lessons, and their worries that the classroom layout and its space might have a detrimental effect on the use of collaborative learning strategies.

1.4 Purpose of the study

The purpose of this study was to develop, pilot, test and research mathematics pedagogies to improve attainment in schools in Saudi Arabia. The pedagogies explored included the use of manipulatives and peer tutoring, both separately and together. The thesis reports investigations using a factor design to explore the effects of incorporating resource-led and peer tutoring pedagogies into the classroom.

The study will examine four elements: the students' attainment, their attitudes towards mathematics, their attitudes towards their learning partners and the developments in their social relationships.

1.5 Study objectives

It is essential to develop techniques for learning mathematics that suit the Saudi context. These learning methods should be easy to apply in a school, and be acceptable to the school's headteacher, classroom teachers and students. Manipulatives appear to be effective tools for learning mathematics when they are used in an appropriate and social way, particularly in the USA, and peer tutoring has shown a similarly significant effect on mathematical education in the UK and other developed countries. Developing methods using peer tutoring, manipulatives or both together, and examining these methods in order to discover which one best suits the Saudi context, is an important undertaking.

Scrutinising existing learning methods is just as important as developing them; therefore, the methods devised by the researcher are examined in this study to evaluate their effects on learning mathematics. Four factors (see below) were analysed to assess whether the learning interventions were effective on the students' learning, their attainments, their attitudes towards mathematics and their learning partners and developments in their social relationships.

Research studies indicate that there is a relationship between improving academic attainment and an increase in students' friendships, self-esteem and attitudes (Eccles, Roeser, Wigfield, & Freedman-Doan, 1999; Masten et al., 1995; Parker, Rubin, Price, & DeRosier, 1995). In other words, there is a connection between the students' achievements and their social relationships (Roseth et al., 2006; Thurston, Burns, Topping, & Thurston, 2012), and it is important to find out if this connection also appears in the Saudi context. Therefore, this research examined whether the relationship between developments in the students' social relationships, their attitudes towards their learning partners, or both, can reliably predict their attainment scores.

Connolly (2009) suggested that Randomised Controlled Trials (RCTs) should involve both quantitative and qualitative data to evaluate the interventions. Therefore, both teachers' and students' perspectives were explored. These were an important part of evaluating the interventions and will provide the researcher with in-depth information about the use of peer tutoring and manipulatives, separately or together, in learning mathematics.

There were therefore four conditions in the experiment: those using manipulatives, those using peer tutoring, those using both manipulatives and peer tutoring together and controls using neither.

With regard to the suggestions above, the objectives of this research are as follows.

1.5.1 Objective one:

- to develop successful pedagogical approaches that raise students' attainment, using peer tutoring and manipulatives, both separately and together, in teaching mathematics to 10 and11-year-old students in Saudi Arabia.

1.5.2 Objective two:

- to develop successful pedagogical approaches that affect students' attitude towards learning mathematics, using peer tutoring and manipulatives, both separately and together, in teaching mathematics to 10 and 11-year-old students in Saudi Arabia.

1.5.3 Objective three:

- to develop successful pedagogical approaches that affect students' attitude towards their learning partner in mathematics, using peer tutoring and manipulatives, both separately and together, with 10 and11-year-old students in Saudi Arabia.

1.5.4 Objective four:

- to develop successful pedagogical approaches that affect students' social relationships using peer tutoring and manipulatives, both separately and together, with 10 and 11-year-old students in Saudi Arabia.

1.5.5 Objective five:

- to discover the effects of using peer tutoring and manipulatives, both separately and together, on those students' attainments.

1.5.6 Objective six:

- to discover the effects of using peer tutoring and manipulatives, both separately and together, on those students' attitudes towards mathematics.

1.5.7 Objective seven:

- to discover the effects of using peer tutoring and manipulatives, both separately and together, on those students' attitudes towards their learning partners.

1.5.8 Objective eight:

- to discover the effects of using peer tutoring and manipulatives, both separately and together, on students' social relationships.

1.5.9 Objective nine:

- to discover if developments in the students' social relationships and their attitudes towards their learning partners affect their attainment scores.

1.5.10 Objective ten:

- to discover the teachers' perspectives of the effects of using peer tutoring and manipulatives, both separately and together, on teaching mathematics in Saudi Arabia.

1.5.11 Objective eleven:

- to discover the students' perspectives of the effects of using peer tutoring and manipulatives, both separately and together, on learning mathematics in Saudi Arabia.

1.6 The study hypotheses

The original hypotheses developed for testing as part of this study were as follows:

H01: In the Attainment Test, there would be no significant change between the pre-test mean scores and the post-test mean scores for each condition.

H02: In the Attainment Test, there would be no significant differences between the experimental groups' mean scores and the control group's mean score.

H03: In the Attitudes Towards Mathematics questionnaire there would be no significant change in the pre-test mean scores and the post-test mean scores for each condition.

H04: In the Attitudes Towards Mathematics questionnaire there would be no significant differences between the experimental groups' mean scores and the control group's mean score.

H05: In the Attitudes Towards Learning Partner questionnaire there would be no significant change in the pre-test mean scores and post-test mean scores for each condition.

H06: In the experimental groups' Attitudes Towards Learning Partner questionnaire there would be no be significant differences between the experimental groups' mean scores and that of the control group.

H07: In the People in Your Class questionnaire there would be no significant change in the pre-test mean scores and students' post-test mean scores for each condition.

H08: In the People in Your Class questionnaire there would be no significant differences between the experimental groups' mean scores and the control group's mean score.

H09: A significant relationship would not be established between the five key sociometric measures (percentage of the members of their class whom they liked to 'work with at maths lesson', 'work with in other lessons', 'share the break time with', 'share the time outside school with' and 'go to the Masjed (the Muslim place of worship) with') in predicting the pattern of attainment in the post-test mathematics scores.

H10: A sufficiently significant relationship would not be established between the five key factors (Rotated expected working, Factor ability, Loading physical fitness, Behaviour, and Popularity) that emerged from the Attitude Towards the Learning Partner questionnaire, to predict the pattern of attainment in the post-test mathematics scores. These five factors will be discussed in further detail in Chapter 5.

1.7 Overview of the study

The research was based on the obvious need to provide education in Saudi Arabia with effective, workable and applicable methods for teaching and learning mathematics at elementary schools, and to examine these methods at policy level.

According to The Ministry of Education in Saudi Arabia (2005), Saudi teachers should be qualified in their subjects, preferably to degree level, and then receive post-graduate teacher training. Teachers are required to use appropriate teaching methods and tools in order to achieve a high standard of teaching.

Elementary-level schooling provides an educational foundation on which students' future learning depends. It is therefore important for them to receive high quality teaching at this stage, in order to equip them with the knowledge and skills they will need later in life.

Ways of using manipulatives in learning mathematics for elementary level students were recommended in a number of studies (e.g., NCTM, 2000; Berk, 1999; Krontiris-Litowitz, 2003; Moch, 2001; Cramer & Karnowski, 1995; Kosko & Wilkins, 2010; Stein & Bovalino, 2001)

Forms of peer learning, including peer tutoring, were recommended in a great number of studies (e.g., Johnson & Johnson, 1994; Topping, 2005; Harris & Sherman, 1973; Pigott, Fantuzzo, and Clement, 1986; Kamps et al., 1994; Vincent & Ley, 1999; Tymms et al., 2011; Roseth et al., 2006; Fitz-Gibbon, 1988; Tolmie et al., 2010; Johnson, et al., 1985; Johnson & Johnson, 1994; Philips & Soltis, 2004; Brophy, 2002).

However, there is a limited number of studies that examine such learning methods for mathematics in Saudi Arabia. As described previously, one experimental study was undertaken in Makkah in Saudi Arabia by Gubbad (2010) on the effect of cooperative learning on academic achievement and the retention of mathematical concepts.

There is an even smaller number of studies applying RCTs in this field, and no studies have examined the effect of using manipulatives and peer tutoring, separately or together, in the Saudi context.

It was these limitations which encouraged this researcher to undertake this project. This study examined the effect of using peer tutoring and manipulatives, both separately and together, on learning mathematics in Saudi elementary schools in AlAhsa city. Fourth-year elementary school students were chosen, the RCT research method was used and there were three experimental groups: one that used manipulatives, one that used peer tutoring and one that used both manipulatives and peer tutoring together. There was one control group that used the usual Saudi method of teaching - effectively, ‘treatment as usual’. The students’ attainments in mathematics, attitudes to mathematics, attitudes towards their mathematics learning partners and developments in their social relationships were measured.

1.8 Significance of the study

This RCT study examined the effect of using peer tutoring and manipulatives, together or separately, on the learning of mathematics at the elementary schools in the city of AlAhsa.

The use of RCTs may yield highly reliable evidence that can be accepted as authoritative by policymakers; therefore, this research study is expected to be important to, and taken seriously by, the Ministry of Education in Saudi Arabia, which is responsible for national educational policy.

The Education Endowment Foundation (EEF) is “an independent grant-making charity dedicated to breaking the link between family income and educational achievement, ensuring that children from all backgrounds can fulfil their potential and make the most of their talents” (EEF, 2014, para. 1). It was established in the UK in 2010 with budget of £125m to support educational research and enhance children’s achievement. With this big budget, large scale RCTs with regard to identifying, researching and evaluating educational innovations for disadvantaged children, and ensuring the effective ones were adopted, could be funded (EEF, 2014). Some educational researchers, policy makers and practitioners have begun to argue for ‘Evidence-Based Education’ (EBE), inspired by the recent rise of Evidence-Based Medicine and the lack of alignment between educational practice and policy and the best available evidence. Researchers at CEM were a key part of that group.

One of the ideas for the EBE was for conferences on Evidence-Based Policies and Indicator Systems. The first international, interdisciplinary conference with this title was held in Durham in 1997. In 1999 the second conference took place, also in Durham, with a third in 2001. The CEM and the UK government's Cabinet Office organised the 2003 and 2006 conferences in London between them. Between 2006 and 2012, the University of York organised the next conference, on RCTs in the Social Sciences, which was held in Durham in 2013. Such conferences can increase the interest in educational research evidence.

The Saudi government has similarly supported a number of efforts and projects in order to make progress in education, particularly in learning mathematics, and this study will help the Saudi education authority to advance this work. The education faculties at the Saudi universities responsible for training mathematics graduates to become teachers can also take advantage of this study, which can help both researchers and teaching staff to establish effective learning methods that they can offer to their trainee teachers.

The evidence, produced from the RCT and scrupulously evaluated, is from a type of research considered to be sound and of high quality; and, as such, it can benefit the education authorities in Saudi Arabia. Not only do they now have learning approaches evaluated through one of the best types of research study, but it also presents them with an approach that can be used to evaluate the effectiveness of teaching and learning methodologies that might derive from other research studies or other countries' successes.

The results of this study indicate that the use of peer tutoring and manipulatives affected both the students' attainments in mathematics and their social lives in a positive way. Students showed self-confidence during the interviews, the overall results of which indicate that, in addition to academic advantages, the use of peer tutoring with manipulatives can help to develop character and increase sociability, all of which, in the long term, lead to a better society.

1.9 Definitions of key terms

1.9.1 Elementary School

Elementary school is where Saudi children receive their first formal academic education. In Saudi Arabia, students study at elementary schools for six years starting at the age of six.

1.9.2 Cooperative learning

Cooperative learning is a teaching strategy that uses small teams, each of which includes students with varying levels of ability and employs different learning activities to improve the students' understanding of a subject. Team members are responsible not only for their own learning but also for helping teammates learn, thus creating an atmosphere of achievement (Kagan, 1994).

1.9.3 Same-age peer tutoring

Peer tutoring is a strategy involving the collaboration of students as they take it in turns in the roles of teacher and student. It creates a link between high- and low-achievers, or between those with similar achievement levels.

1.9.4 Manipulatives

According to Moyer (2001), mathematical manipulatives are

> objects designed to represent explicitly and concretely mathematical ideas that are abstract. They have both visual and tactile appeal and can be manipulated by learners through hands-on experiences. Manufacturers advertise manipulatives as materials that will make the teaching and learning of mathematics "fun" and promote their products as catalysts for engaging students in mathematical learning (p. 176).

1.9.5 Randomised Controlled Trial (RCT)

A randomised controlled trial (RCT) is a type of experimental research methodology that is often used to discover the effectiveness of an intervention in a population.

1.9.6 The National Council of Teachers of Mathematics (NCTM)

The National Council of Teachers of Mathematics (NCTM) is "the public voice of mathematics education, supporting teachers to ensure equitable mathematics learning of the highest quality for all students through vision, leadership, professional development, and research" (NCTM, 2013).

1.9.7 Attitude

Attitude is defined as a "settled way of thinking or feeling about something" (Oxford Dictionary Online, 2013).

1.9.8 Attainment

Attainment refers in this study to academic progress that can be validated by testing.

1.9.9 Social relationship

Social relationship refers in this study to the students' friendships, in quantity and quality, in and out of school and with both other students and their teachers.

2 CHAPTER TWO: LITERATURE REVIEW

This chapter discusses the literature related to this study, covering three main areas. The chapter will be structured as follows. Learning theories will be discussed in Section 2.1, starting with developmental psychology, followed by social constructivism, then metacognition, and will subsequently move on to an examination of the nature of the student and the roles of teachers with regard to theories of learning, and finally to the elements of an effective learning approach. Section 2.2 will discuss forms of social constructivist theory. Section 2.3 will examine theories of peer learning, comprising cooperative learning and peer tutoring, and will then identify the critical elements of cooperative learning found in peer tutoring. Theories on the learning of mathematics will be examined in Section 2.4, while combining the use of peer tutoring and manipulatives in learning mathematics in the literature will be discussed in Section 2.5. The final section in this chapter, Section 2.6, presents an overview of the education policy in Saudi Arabia.

2.1 Learning theories

This thesis aims to research, pilot, test and develop mathematical pedagogies to improve attainment in schools in Saudi Arabia. To fulfil this aim, it is necessary to examine various learning theories in order to determine which potentially offers the approach best suited for effective application in Saudi schools. A number of approaches focusing on different elements have been developed through these theories. In the following section, several of these theories will be examined to identify which develops the most appropriate intervention for application in Saudi schools.

2.1.1 Developmental psychology

Cognitive theories of learning were developed as a response to limitations to the behaviourist perspective of the understanding of learning, which emerged over a century ago. Behaviourism proposes that behaviour is developed through conditioning (Skinner, 1953), which results from people's reaction to their environment, and can be studied systematically with no consideration of internal mental states. Behaviourists hold that learners are recipients, responding to specific stimuli (Philips & Soltis, 2004). Behaviourism assumes that the environment controls behaviours, in that learners begin life as 'clean slates' and are then 'written on' by their environment (Ormrod, 2004). The constructivist approach is one of the most significant cognitive theories of learning to emerge to challenge behaviourist views. To give a clear overview of this approach, two main theories will be investigated - cognitive constructivism and social constructivism.

Cognitive constructivism is an idea based on the work of Jean Piaget, the Swiss developmental psychologist and philosopher. Piaget worked with a small number of children and identified the development of what became known as cognitive structure (Philips & Soltis, 2004; Pritchard, 2013). This refers to children's individual construction of their own basic knowledge, which they have absorbed from experience, to guide them in building their own ideas (Philips & Soltis, 2004).

Piaget (1950), who also identified the stages of cognitive development, made a number of interesting points. One was that the mental phenomena should be related to the origins of intelligence, defining the response as the practical interaction that can occur between the external word and the subject. However, psychological phenomena cannot be studied without considering other influential internal and external factors: the adaptation, in Piaget's view, is the balance that humans can make between their actions and the environment.

According to Piaget, cognitive development has four main stages. The first is the sensory motor stage, which lasts from birth until two years of age. In this stage, children differentiate themselves from objects. For example, if they want to make a noise, they shake their toys. The second stage is the pre-operational stage, which lasts from two to seven years old, and in which children can use language to describe objects using pictures and words and understand viewpoints with some difficulty. The third stage, which lasts from seven to 11 years old, is the concrete operational stage in which children start to think logically - for example, they can put things in order – and the final stage is the formal operational stage, which begins at around 11 years old, 54 and in which children can think logically about abstract things (Atherton, 2013; Philips & Soltis, 2004).

Piaget's work focuses on learners' individuality, explaining learning as an individual process. It focuses on what happens inside the learner's brain and the process learners' brains undergo when building their own knowledge. Those who follow Piaget's approach commonly believe that knowledge is characterised by using symbols in the brain's process, meaning that the knowledge people have is transferred in their brains into different symbols.

Berk (1999) stated that using manipulatives is one of the best ways of presenting concepts on an abstract level. They can establish a solid foundation of concepts and using them provides students with a greater opportunity to gain a deep and effective understanding of such concepts (Schweyer, 2000).

According to Schmeinck and Thurston (2007), students who are 10 years old can develop spatial cognitive representation when they have experience of and exposure to travel. The study indicated in its literature that children in the concrete operational stage are in the process of developing their own cognitive abilities. However, there is debate about the age at which children can develop these abilities. Blades et al.

(1998) state that this development can be observed in four-year-old children; however, Towler and Nelson (1968) hold that children cannot develop this ability unless they are in the concrete operational stage. Since the early 1980s, the interpretation of the work of Piaget has shifted from the strict interpretation of stages of development to a more flexible one, with research indicating that children can develop cognitive abilities in Piaget's chronology as early as three years old. The above literature shows that children's knowledge, background, environment and experiences might help them to develop their cognitive level and achieve higher stages.

2.1.2 Social constructivism

That learners are passive is one of the main ideas emerging from the theory of behaviourism. The social constructivist perspective argues that a learner is at the centre of the learning process and that learning is mediated through social interaction. Currently in Saudi Arabia passive, teacher-centred learning remains the norm despite a shift to interactive learning in many other countries in recent years. This section will focus on social constructivism and consider different criteria in order to make a thorough analysis of social constructivism as a learning approach. This is important as it will form the basis of the pedagogical design and interpretation of data in this thesis. Different accounts of the approach will also be considered. In the current academic world, constructivism appears to dominate the educational process (Fox, 2001). The first criterion to be used in this paper is the adequacy of the underlying assumptions in each account. The logical coherence of each account will also be considered, together with evidence of the strength of each in comparison to the others.

The Russian physiologist Vygotsky (1896-1934) developed the theory of social development. This argues that social interaction is central to development as it mediates the learning process as it evolves, and that both consciousness and cognition are the final outcomes of social behaviour.

According to Vygotsky (1987), interaction through speech has great value in the learning process. Children generally develop their own ways of understanding and solving the problems they might face; and speech interaction comes as the first step in this, which means they might deal with these problems abstractly. One of the most interesting points Vygotsky made is that children can find ways to develop quickly and might reach the abstract level sooner or later, depending on the value of mediation they receive. It is worth noting at this point that although Piaget and Vygotsky, whose work was only made available to the wider public from the late 1970s onwards, worked on similar theories simultaneously.

Another interesting area explored by Vygotsky is the role of mediation in child development. He observed that higher mental functions developed historically within particular cultural groups, as well as individually through social interactions with significant people in a child's life. These are usually parents; however, as a number of research studies have indicated, they can also be other adults and peers. In the course of his work, Vygotsky realised that children absorb the mind-set of their culture through the culture itself and their environment. Furthermore, the activities in which children engage within their society can help them to learn and improve the most important skills they might need. All children develop both their own tools and their own, unique uses for them.

Vygotsky (1978) described interaction between students as an effective method with which to develop their skills and strategies. Teachers use cooperative learning forms, where the tutor mediates the tutee’s learning within the zone of proximal development. Vygotsky believed that when a student is solving a learning problem in the ZPD, providing suitable help will enhance the student’s ability to succeed in the task. In other words, the tutee will achieve a better quality of learning when it is mediated by the tutor than when he or she learns alone. Vygotsky's theory draws three main conclusions. Firstly, social interaction plays a fundamental role in the cognitive development process.

According to Vygotsky (1978),

> Every function in the child's cultural development appears twice: first, on the social level, and later, on the individual level; first, between people (interpsychological) and then inside the child (intrapsychological) (p. 57).

This shows how important a role social activities play in a child's cognitive development.

Secondly, although the significant other refers to a person who has more knowledge than the learner, such as a teacher or coach, they can also be a peer, a young person, or anyone else who can enhance the development of the learner's knowledge.

The third conclusion is that the learning takes place between the student's ability to address a task under adult supervision or peer cooperation and their ability to solve the problem independently. This phenomenon is called the 'Zone of Proximal Development' (ZPD).

Vygotsky defines the ZPD as

> the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers. (Vygotsky, 1987, P.86).

According to Vygotsky, culture plays important role in the learning process as learners use tools that have been developed in the sociocultural context. These tools help learners achieve higher levels of thinking skills. Vygotsky's theory shows how important the active roles in the learning process are. It also bridges the gap between what is known and what can be known. In other words, within the social learning environment students build their own knowledge through cooperation with adults or peers with better or more experience. Currently, in Saudi Arabia, instruction is teacher-centred and students are entirely passive, as mentioned previously. This study seeks to determine whether students' learning would be enhanced by active participation in their own learning, through interaction both with teachers and with peers, and by the use of tools, in line with Vygotsky's theory.

Social constructivism is an approach that identifies learning as a social process: that is, learners construct their knowledge socially, learning from each other. In this approach, social activities have valuable roles. Each person, according to social constructivism, can simultaneously be a learner and a teacher with their own important and effective role in the learning process (Philips & Soltis, 2004). Sciences, such as mathematics and chemistry, are socially based: they are built and improved through people's needs, such as discovering new power resources and developing new tools (Philips & Soltis, 2004). Every society also has its own constructs of learning. Humans lead social lives, thereby supporting the social constructivists' beliefs (Philips & Soltis, 2004). According to Gredler (1997), there are three main differences between personal constructivism and social constructivism. These differences are the way in which knowledge is defined, the way in which learning is defined and the location of learning. Brophy (2002) concluded the introduction of his book "Social Constructivist Teaching: Affordances and Constraints" with some suggestions and recommendations for those interested in the constructivist approach, indicating a number of points for emphasis. Firstly, meaningfulness is the real aim of learning: that is, learners must construct their knowledge for use in their own lives and must use new information at the most appropriate time. A teacher's role is to build a social environment and use it to help students achieve the highest level of understanding. Brophy holds that both teachers and students are important components in the education process and appreciating their different roles can help reach meaningful understanding. Lessons must be well organised and have clear aims; and they should stimulate students and give them opportunities to raise questions which can encourage meaningful learning.

This explains both Brophy's stance on the role of both learners and teachers, particularly teachers who are responsible for preparing lessons, as well as the importance of giving students opportunities to raise questions during lessons and of helping them search for a deeper understanding as opposed to simply being receptive students. Encouraging students to raise questions can help teachers identify and explain any unclear concepts during the learning process.

Classroom environments should be active environments and should encourage discussion throughout the learning process. Discussion emerges as one of Brophy's (2002) preferred methods because it can help students become active learners and encourage their involvement in activities that can help teachers to ensure meaningful understanding is taking place. Moreover, students should build their own knowledge through discourse and exchange of experiences. In Brophy's (2002) opinion, although teachers have important and effective roles in the learning processes, learners are responsible for taking advantage of the discourses provided by teachers in order to build their knowledge. Although this advice and these recommendations were intended for teachers who want to use a social constructivism approach, they also give some insight into how it might work.

In order to develop an effective learning approach which improves Saudi students' mathematics learning, a number of approaches could be taken into consideration, including an approach based on social constructivist theories in which the students are central to the learning process and enhance the learning mediation. This present study seeks such an approach, as currently in Saudi Arabia, learning outcomes in mathematics, as well as in other subjects, are generally poor. Hence, it is of great importance to find an approach which will improve these outcomes. Further, when such an approach has been identified, it is vital to test it to ensure that it will be effective in Saudi Arabia and be appropriate to Saudi culture.

2.1.3 Metacognition

Metacognition is a model of cognition introduced by Flavell in 1979 and defined as "cognition about cognition", or "knowing about knowing". Psychologists interested in cognitive psychology defined metacognition as "Awareness and judgement about an event gained through experience" (Israel, Bauserman, & Kinnucan-Welsch, 2006, p. 4); "The knowledge and control children have over their own thinking and learning activities" (Cross & Paris, 1988, p. 131) and

> Awareness of one's own thinking, awareness of the content of one's conceptions, an active monitoring of one's cognitive processes, an attempt to regulate one's cognitive processes in relationship to further learning, and an application of a set of heuristics as an effective device for helping people organize their methods of attack on problems in general (Hennessey, 1999, p. 3)

"Awareness and management of one's own thought" (Kuhn & Dean, 2004, p. 270) and "The monitoring and control of thought" (Martinez, 2006, p. 696).

Metacognition is what allows the student to apply a practical strategy that has been taught for a specific task to a similar but different task (Kuhn & Dean, 2004). Schraw (1998) explained metacognition as a multidimensional set of general skills.

There are two kinds of metacognition. The first is metacognitive knowledge and the second is metacognitive experience (Cross & Paris, 1988; Flavell, 1979; Paris & Winograd, 1990; Schraw & Moshman, 1995). According to Griffith and Ruan (2005),

> Metacognitive knowledge is characterized as combinations of information around three knowledge variables - self, task, and strategies - that will be effective in achieving the goal of the task (p. 4).

The theory implies that students have knowledge about their knowledge, suggesting that they could engage in any learning environment, control it, and target their learning. By so doing, they have the ability to enhance their cognitive development (Kluwe, 1982; Brown, 1987; Kuhn, 2000, Thurston et al., 2007). According to Thurston et al. (2007), “Metacognitive is likely to promote more effective onward learning” (p. 485).

Flavell (1979) stated that there are three types of cognitive knowledge. The first type is ‘person’ knowledge that encompasses all beliefs around cognitive processors. The second type is ‘task’ knowledge that encompasses knowledge around an awareness of different tasks. The third type is ‘strategy’ knowledge that includes an awareness of the most suitable strategies for different tasks.

Researchers interested in metacognition have disagreed over the framework for classifying cognitive knowledge. First of all, the concept of declarative and procedural knowledge has been used by a number of researchers to clarify the differences between the cognitive knowledge classifications (Cross & Paris, 1988; Kuhn, 2000; Schraw, Crippen, & Hartley, 2006; Schraw & Moshman, 1995). Kuhn and Dean (2004) described declarative cognitive knowledge as the student’s general ability to understand thinking and knowing. However, Schraw et al. (2006) described cognitive knowledge as students knowing about themselves as learners and the factors that might affect their own learning, whereas Paris and Winograd (1990) explained the procedure of self-assessment as the student's ability to answer the question, 'Do I know this?'. Cross and Paris (1988) explained declarative cognitive knowledge as the ability to be aware of things that could influence learning capacity.

From the other point of view, strategic knowledge includes the ability to manage cognition which involves a student's knowledge of the appropriate strategy to be applied to each different task (Cross & Paris, 1988; Kuhn & Dean, 2004; Schraw et al., 2006). Schraw et al. (2006) stressed that cognitive knowledge is difficult for young students to develop, as they sometimes show limited cognitive knowledge themselves. In addition, although the ability to explain cognitive knowledge appears to develop with age, many adults find it difficult to describe their understanding of their own thinking. Students do not need to explain their cognitive knowledge verbally to be able to access and use it.

The other element in metacognition is the supervision of a student's cognition. A number of researchers have explained that monitoring cognition would include learning activities such as planning, directing and assessing (Cross & Paris, 1988; Paris & Winograd, 1990; Schraw & Moshman, 1995; Schraw et al., 2006; Whitebread et al., 2009). Among planning activities would be choosing the appropriate strategy, allocating the best resources, target setting, recalling needed knowledge and time management. Directing would include being aware of understanding and undertaking tasks. Assessing would include reflecting on the outcomes of learning in relation to the stated goal.

There is a relationship between cognitive knowledge and the cognitive monitoring experience. According to Flavell (1979), metacognitive experience plays an important role in metacognitive knowledge. Schraw (1998) concluded that knowledge seems to facilitate the control of cognition, arguing that cognitive knowledge and cognitive control are strongly related. According to Schraw and Moshman (1995), both cognitive knowledge and cognitive regulation are combined in metacognitive theory.

A number of researchers have indicated a relationship between metacognition and motivation (Cross & Paris, 1988; Eisenberg, 2010; Martinez, 2006; Paris & Winograd, 1990; Ray & Smith, 2010; Schraw et al., 2006; Whitebread et al., 2009). According to Gottfried (1990), motivation is the "enjoyment of school learning characterised by a mastery orientation, curiosity, persistence, task-endogen and the learning of challenging, difficult and novel tasks" (p. 525). In relation to metacognition, Schraw et al. (2006) defined motivation as "beliefs and attitudes that affect the use and development of cognitive and metacognitive skills" (p. 112).

According to Cross and Paris (1988), metacognition contains emotion and motivation. Martinez (2006) indicated that metacognition can improve perseverance and the motivation to solve challenging tasks. Emotion is an important part of metacognition (Paris & Winograd, 1990).

A number of studies built on Piaget's work have indicated that young children do not have the ability to understand abstract ideas. Several authors have argued that this is a skill that develops as the child grows older (Flavell, 1979; Schraw & Moshman, 1995; Whitebread et al., 2009) and challenged the idea of children being incapable of developing metacognitive skills. However, Schraw and Moshman (1995) suggested that children as young as four are capable of developing their own simple thinking skills. During problem-solving processes, children between the ages of three and five have shown the ability to apply, both verbally and nonverbally, metacognitive characteristics such as cognitive knowledge and cognitive regulation (Whitebread et al., 2009). Schraw and Moshman (1995) showed that children can understand their own thinking at the age of six, while Hennessey (1999) indicated that first grade students can comprehend the scientific concepts they learn.

The literature on metacognition suggests that in order to develop an effective learning approach, it is necessary to be aware of the involvement of the metacognitive skills in such an approach. The current approaches in use in Saudi Arabia appear not to take metacognition into account. Therefore, it is of considerable importance in Saudi Arabia to search for an approach which has been shown to be effective in enhancing metacognitive skills.

A number of studies have suggested that the use of cooperative learning strategies can enhance metacognitive skills (Cross & Paris, 1988; Hennessey, 1999; Kramarski & Mevarech, 2003; Kuhn & Dean, 2004; Martinez, 2006; Paris & Winograd, 1990; Schraw & Moshman, 1995; Schraw et al., 2006). These suggestions were developed through the ideas of Piaget and Vygotsky. Cross and Paris (1988), indicated that group discourse is one of the most important parts of the Informed Strategies for Learning curriculum. Hennessey (1999) stressed that the use of strategies that encourage metacognitive discussion helps students to understand conflicting ideas which can clarify their concepts. Kramarski and Mevarech (2003) suggested that the high level of students’ performance during cooperative learning results from the high quality of discussion when they work together. Furthermore, in these studies, students involved in cooperative learning were found to be more capable of explaining their mathematical thoughts in writing than those who worked individually. According to Schraw and Moshman (1995), peer communication can improve metacognitive skills, cognitive knowledge and cognitive experience, while social activities in the classroom help students to increase their ability to explain what they have learned (Kuhn & Dean, 2004). Students were reported as being able to develop metacognitive skills through both practical and social learning methods (Palinscar & Brown, 1984).

Metacognition was found to have improved at the end of the intervention when the students were given more opportunity to be consciously engaged in their learning by informing them about what they learn, how they learn and the importance of what they learn (Kuhn, 2000). Metacognition takes place through the application of social learning methods in the learning environment (Brown, 1987). Students control their own learning; and ought to be aware of what they should be learning, the best way of learning it and the benefit of this learning (Reynolds, Wade, Trathen, & Lapan, 1989).

According to Perfect and Schwartz (2002), "Flavell was interested in finding out if the improvement in children's memory abilities was a function of greater conscious understanding of rules that govern memory and cognition" (p. 3). However, Flavell found no critical evidence of a relationship between metacognitive thinking and improving memory (Perfect & Schwartz, 2002).

Thus, there is evidence to suggest that metacognitive skills can be developed through social learning approaches. The greater a role the student plays in the learning, the greater will be the improvement in his or her metacognitive skills. However, currently in Saudi Arabia, teachers are largely unaware of metacognition and of social learning approaches. It is therefore essential that awareness be raised of the importance of developing students' metacognitive skills and of the part that social learning approaches may play in this development. It is proposed that the use of social learning approaches may enhance the metacognitive skills of students in Saudi Arabia.

2.1.4 Examination of the nature of the student and the roles of teachers with regard to theories of learning

As learners and teachers have the most important roles in the teaching and learning process, the above theories of learning explain both learners' and teachers' roles with regard to these theories. The following section will consider the nature of the learner and the role of the teacher with regard to learning theories.

2.1.4.1 The nature of the learner

From the perspective of the behaviourist, learners are recipients, as they respond to specific stimuli (Philips & Soltis, 2004). Behaviourists believe that nature and environment can explain human behaviour and that learners act as intermediaries between behaviour and the environment. One basic assumption is that behaviours are controlled by the environment: that is, learners are born as 'clean slates' and then written on by their environment (Ormrod, 2004). Behaviourism notes the effect of experience and its role in helping learners to accumulate their own knowledge.

On the other hand, cognitive constructivists believe that learners are, and have to be, actively involved in the learning process, constructing and enlarging their body of knowledge themselves rather than being recipients of knowledge from others. Learners, additionally, build their own meanings (Poplin, 1988). If learners were merely recipients, teachers would not be sure what students understood and whether they had understood some things incorrectly. In other words, creating an active learning environment and involving students in activities such as group discussion will benefit teachers and learners simultaneously: teachers, by confirming what students actually understand, and students, by using their teachers' feedback to reach levels of meaningful understanding. Learners, Piaget believes, build their knowledge step by step through active involvement in learning processes.

According to social constructivists, learners are active. Social constructivists believe that each learner is an important and effective part of the learning process, acting simultaneously as learner and teacher. Every learner participates significantly and effectively in the learning process (Philips & Soltis, 2004). The learner can positively interact with other learners in the social learning environment, using cognitive tools such as hands-on and manipulatives (Gredler, 1997; Prawat & Floden, 1994). In this way, learners learn socially, using socially constructivist skills and cognitive tools to impose meaning on the process of social learning. The learner is actively involved in the learning environment that is created and developed by the teachers (Gredler, 1997). In other words, the teacher's role is to create a socially active learning environment, then develop this environment and learners learn through it with others. The vision of the learner is extended by the learning community and individual understanding (Gredler, 1997).

As can be noted from the above, both theories of constructivism explain learners' roles in learning processes; however, behaviourists give less importance to learners' roles. However, teachers in Saudi Arabia appear to be largely unaware of theories of constructivism. Their approach to teaching involves controlling the class, and imparting knowledge to the students who remain passive recipients rather than active participants in learning. It is therefore crucial to raise awareness among Saudi teachers of the benefits to be gained from encouraging students to become more engaged in learning through communication with each other and with the teacher. The following section will provide a more in-depth discussion of the roles of teachers with regard to the learning theories.

2.1.4.2 The roles of educators

From a behaviourist perspective, the educator's role is to provide texts and supervision, and to give learners feedback during the learning process (Kimball &

Heron, 1988). However, this is very difficult, considering the mixed abilities of learners, as it is unlikely that learners who are all at the same level will be found. The primary role of the educator is to maintain an appropriate reasonable environment that can help students reach the expected level of education. Direct teaching approaches and guided instruction can be used in behaviourist teaching and learning processes (Jacob & Borland, 1986) and educators should expect specific learning outcomes.

From a cognitive constructivist perspective, educators have different roles. Cognitive constructivists believe that each learner uses his or her individual experience to build understanding, and abstract special meaning, concepts and knowledge. Educators must provide tools to help their students, but the outcome can be meaningless if learners do not engage in active learning (Glaserfeld, 1983). The role of the educator here is to use previous experience to construct new understanding. Learners apply their own understanding later but must be engaged in active learning in order to build their own knowledge (Pritchard, 2013).

People can use the knowledge they gained previously through learning processes or experiences to deal with new experiences that they might face. This can be similar in the teaching and learning process; for example, in teaching and learning mathematics.

Social constructivists assign the educator different roles according to the approach used. Different approaches have been established regarding the social constructivism theory and each approach has set roles for educators. In general, their role is to assist in the classroom during discourse and arrange the learning environment (Brophy, 2002). The role of the educator in social constructivism is to facilitate and assist the students during the learning processes, not to transfer mathematical knowledge to them (Irvin, 2008). The role of social constructivist teachers is to encourage learning in the classroom to be, essentially, an investigation (Beck & Kosnik, 2006).

2.1.5 Elements of an effective learning approach

The use of social constructivist learning theories appear to be effective in enhancing learning in that they promote the roles of both the students and teachers. These theories encourage students to engage actively in their own learning and the teachers to assume the role of guide and facilitator of this learning. According to certain of the social constructivist learning theories, the development of any effective learning approach should include several elements. Among these is a social learning method that maximises the students' contribution and places the students at the centre of the learning process, while another of these is good lesson planning. In addition, the use of the time allotted for the class should be optimised through efficient time management.

2.2 Forms of social constructivist theory

Two main factors of the constructivist approach can help explain an idea more fully: active learning, which was proposed by Bonwell and Eison (1991) and discovery learning.

In active learning, learners assume all responsibility for their learning, meaning that they control it and must acquire their own knowledge. Bruner (1961) stated that learners were more likely to understand the knowledge they are expected to absorb if they studied in active environments and were actively involved in processes during the learning process. Active learning can include variations of learning such as class discussion, debate, think-pair-share activities, short written exercises, case studies, and seminar presentations (Bonwell & Eison, 1991).

Although active leaning can be used either to build new knowledge or to review current knowledge, there is debate as to the best way it can be used in order to achieve the greatest benefits. In other words, the argument concerns at which stage of the learning process active learning should be used. According to Sweller (1988), the use of active learning in solving problems and building concepts may create knowledge gaps and misunderstandings. Therefore, there are two roles for teachers, whose main role is to guide students through the active learning process. The first is to build a base on which students can build their understanding. The second is to fill any gaps and clear up any misunderstandings that may have arisen. Worked-examples is a cognitive load-reducing technique which focuses on the steps involved in solving a problem rather than simply on the solution to the problem (Sweller and Cooper, 1985). Sweller (1988) suggested that to achieve the greatest benefit from active learning, learners should study worked-examples because this is a more successful and effective method of initial instruction than a number of other instructional techniques. For example, Sweller and Cooper (1985) found that students who used worked-examples performed significantly better than those who actively solved problems.

However, Kirschner, Sweller, & Clark (2006) advise teachers to be cautious when implementing and encouraging their students to use the worked-example method. Learning can be negatively affected, particularly when students are already familiar with the subject matter, and their desire to learn may decrease, affecting their understanding (Kirschner, Sweller, & Clark, 2006). Therefore, teachers should take care to use the method judiciously.

The second method, of which Dewey and Bruner are the most cited advocates (Dewey, 1938; Bruner, 1961) is discovery learning, which actively engages learners and encourages them to ask questions, formulate hypotheses and experiment with them as they learn, take responsibility for setting their own learning goals and discover and apply whichever methods can best help to achieve them.

There are two main goals associated with discovery learning: the development of knowledge about discovery, and the development of skills that facilitate the development of knowledge about the domain. Discovery learning is a method of 'learning by doing'. It supports the viewpoint that students have a better chance of remembering concepts if they discover them for themselves rather than being instructed or guided towards them.

In order to explain discovery learning, this section will focus on a number of its processes and how they can be brought about. Friedler, Nachmias and Linn (1990) list the processes of discovery learning as defining a problem, stating a hypothesis, designing an experiment, observing, collecting, analysing and interpreting data which help to apply the results and, finally, making predictions based on the results of previous experiment(s). However, Veermans (2002) lists the stages as orientation, hypothesis generation, hypothesis testing, conclusion and regulative processes. Orientation is the process whereby learners establish their first ideas of the domain and the learning environment. A reading test, for example, might be provided as a base. Hypothesis generation gives learners the opportunity to begin formulating hypotheses about the problems and questions of the domain which they then test. In conclusion, learners must justify the hypothesis with supporting evidence. Finally, the regulative process is what students undergo when managing all the other processes.

It is apparent that learners reach the highest level of understanding when they can present clear and logical evidence.

As has been shown, the ideas and theories relating to constructivism are significant and continually developing in various ways. However, it is important to consider the strengths and weakness of constructivism. One of the most important works to clarify concepts about constructivism is Fox's (2001) article entitled "Constructivism

Examined”. Therefore, Fox’s article will be highlighted in this section. First, the main claims of the social constructivist are summarised then examined. The first claim is that “learning is an active process”, which Fox discounted, believing that learning could be an active and passive process simultaneously and that the brain is active even during the passive process (Fox, 2001 p.24). The second claim is that “knowledge is constructed, rather than innate, or passively absorbed”, was refuted as the cognitive system of humans is quite complex and advanced humans have a natural ability to learn (Fox, 2001, p.26). The third claim is that “knowledge is invented not discovered”, but according to Fox (2001, p. 26), humans must discover the knowledge as it is already in existence.

The fourth claim is divided into two parts, the first being that “all knowledge is personal and idiosyncratic” and the second that “all knowledge is socially constructed” (Fox, 2001, p. 29). This dual claim illustrates the difference between cognitive constructivism and social constructivism and the extent to they are the opposite of each other. Prior knowledge will affect what is learnt (Fox, 2001).

The fifth claim is that “learning is essentially a process of making sense of the world”. Fox (2001) objects to this claim by highlighting the differences between the brain’s various processes. The human eye views things as they are, but interpretations of what is seen differ depending on previous knowledge and experience. Human brains are able to store these pictures and recall them when necessary. Moreover, although new information requires previous knowledge to be explained in the mind, it is not important that all new knowledge should carry some reference to prior knowledge, although this is necessary for assimilation to take place (Fox, 2001).

The sixth claim is that “effective learning requires meaningful, open-ended, challenging problems for the learner to solve” (Fox, 2001, p. 33). Fox also objected to this idea, believing that every object or activity could be interesting and attractive to humans and that for this reason the problem-solving approach was unsuccessful or unimportant. This approach also runs counter to the concept of social constructivism as it implies an artificial effort is necessary to construct knowledge (Fox, 2001). As has been shown, Fox made serious objections to the claims of the theory of social constructivism, encouraging caution when using the social constructivist paradigm.

A number of methods of learning have been developed through the theory of social constructivism. Thurston, Christie, Howe, Tolmie, and Topping (2008) investigated the effect of continuing professional development (CPD) on group work practices. Data were collected from 24 primary school classrooms, from which 332 students aged from 9 to 12 years old and 24 primary school teachers comprised the sample for the study. Significant changes were observed in science attainment and significant increases in classroom discussion and communication were attributed to the CPD. Moreover, the teachers' performances were positively affected by the CPD as they became researchers into their own professional practice. According to the study, "CPD can facilitate changes in the professional practice of teachers. However, it must be supported by carefully structured opportunities to allow teachers to draw support and advice from each other" (Thurston et al., 2008, p.279).

2.3 Theories of peer learning

Peer learning is the "acquisition of knowledge and skills through active help and support among status equals or matched companions" (Topping, 2005, p.631).

From Topping's (2005) definition a number of important conclusions can be drawn. Firstly, knowledge and skills can be gained through peer learning. Secondly, this knowledge and these skills are gained through active help and support. Thirdly, the helper can be the social equal of the one being helped. The following paragraphs will clarify peer learning and its forms, as well as its organisation and process and how it can be implemented.

Duran (2010) cited a variety of ways, generated by a number of studies, in which interest in peer learning could be increased. First, it is essential for teachers, parents and any others who might have to use a given method, to have had instruction in its use that can be followed successfully (Ainscow, 1991). Peer learning and its implications have these clear instructions, which can therefore facilitate their use. A peer learning strategy can help to encourage and build a democratic society (Slavin, 1995), which nowadays is one of the most important aims in a great number of countries and organisations worldwide. Building such a society is an idea supported by religions, and might be one of the most important factors in networked learning (Heller, Hockemeyer & Albert, 2004). However, Duran (2010) stated that there is debate over the best framework for peer learning. Therefore, researchers have undertaken a number of studies and suggested a number of frameworks to discover the best way to manage peer learning. Two frameworks stand out from the others: peer tutoring and cooperative learning.

Topping (2005) explained the various components of peer learning. The old-fashioned peer helper was like today's support teacher or teaching assistant: thus, the teacher-in-charge transfers the knowledge to the peer helper who conveys it to students. However, there is a feeling nowadays that peers should have a cognitive challenge, which means that the student benefits from the helper's actions and the helper similarly benefits from the opportunity to gain a deeper understanding of the subject before attempting to teach it. The following table summarises the variations in the organisation of methods of peer learning (PL), according to Topping (2005).

Table 2-1: Summary of the variations in the organisation of methods of peer learning (PL) (Source: Topping, 2005, p.633-634)

	The organisational issue	Explanation
1	Curriculum content	What should be covered, such as knowledge, skills or a combination of the two. There is evidence that PL can be used for a wide range of projects and subjects.
2	Contact constellation	The ways of organising PL can vary. One helper might work with a group of peers, and the number of learners in each group may also vary, as may the number of helpers.
3	Within or between institutions	PL can be undertaken either in a single institution, or between two or more institutions. For example, a group of students who study at a high school can be helpers in their neighbourhood elementary school.
4	Year of study	The helpers can be people studying at the same level as, or different level from, the learner group. They might also be people in the same or a different age group.
5	Ability	Most PL projects worked with mixed-ability groups. However, there is increasing interest in same-ability PL, which may have a number of advantages such as deep and accurate understanding.
6	Role continuity	Roles can be fixed, with tutors and tutees remaining in role for the duration of a project. However, roles may change in reciprocal role peer tutoring, with each member of the pair taking turns at being both tutor and tutee.
7	Time	PL can be undertaken at different times, such as classroom contact time or other times.
8	Place	PL is flexible and can be undertaken almost anywhere.
9	Helper characteristics	Whatever the academic level of the helper, there should be a challenge for all involved in PL. Although the helpers may not appear to benefit greatly from PL, the overall result shows their performance does improve.
10	Characteristics of those helped	There are projects aimed at everyone in a group and others which aim at a sub-group within in the main group, such as the very able, those with learning difficulties and those at risk from under-achievement including the gifted and talented and other learners with specific special needs. These differences within groups create differences in the characteristics of those helped.
11	Objectives	"Projects may target intellectual (cognitive) gains; formal academic achievement; affective and attitudinal gains; social and emotional gains; self-image and self-concept gains or any combination of these. Organisational objectives might include reducing dropout, increasing access, and so forth."
12	Voluntary or compulsory?	Volunteers may or may not be needed, depending on the type of project and the needs of the participants.
13	Reinforcement	"Some projects involve extrinsic reinforcement for the helpers (and sometimes also the helped), while others rely on intrinsic motivation."

Topping (2005) offered evidence that different forms of PL are effective in different situations. Evidence of peer tutoring on a large scale is given by a number of researchers, including Fuchs et al. (1997) and Mathes, Howard, Allen, and Fuchs (1998) and Topping (2005) who observed,

> Peer learning has moved from a method perceived as being only for a few selected learners, to a method used on a class-wide equal opportunity and inclusive basis. Some schools have developed whole-school approaches to the deployment of various forms of peer learning (p.642).

2.3.1 Cooperative learning

Cooperative learning is another method that has been developed from social constructivism. It is a teaching strategy that uses small teams, each of which includes students with varying levels of ability, and different learning activities to improve the students' understanding of a subject. Each team member is responsible not only for learning what is taught for themselves, but also for helping teammates learn, thus creating an atmosphere of achievement (Kagan, 1994).

According to Lin (2006), "Cooperative learning is an instructional method in which students work in small groups to accomplish a common learning goal under the guidance of a teacher" (p. 34).

A number of research studies examined the method. Thurston et al. (2009) reported that using cooperative learning strategies positively affected students' performance. In addition, positive interaction and discourse reaction were noticed through the study.

A number of features differentiate cooperative learning from other group learning strategies. First, students in cooperative learning should depend on each other in a positive way, in order to achieve their learning goal together. Such students engage in face-to-face learning activity; should be assessed individually and for what they themselves are responsible; should use and improve the collaborative and interpersonal teaching skills needed for this method of learning and should develop feedback from their learning activity in order to test its effectiveness for use in future learning activity (Johnson & Johnson, 1999; Kagan, 1994).

Cooperative learning reduces individuality and individual competitive behaviour and encourages students to cooperate in group activities as they learn (Cooper, 1990; Johnson et al., 1998; Joyce et al., 1987; Marzano et al., 2000; Millis, 1995; Slavin 1991; Stahl & VanSickle, 1992). When students learn in this way they develop their learning skills from apparently superficial engagement with their learning to deep engagement, understanding facts, concepts and ideas. Cooperative learning skills help students by providing a social context within which they can actively engage with learning.

There are three main reasons for using cooperative learning: increasing and improving students' social and communication abilities; helping students to accept their differences and enhancing academic achievement in a very positive way (Lin, 2006).

According to Sharan, Kussell, Brosh, and Peleg (1984), students tend to be less individually competitive, and freer to work and cooperate more with students from other ethnic backgrounds when they participate in cooperative learning.

Johnson and Johnson (1999) stated that with cooperative learning more social relationships with other students with special needs and different ethnicities were observed.

According to Joyce et al. (1987), teachers involved in a survey of modern teaching techniques aimed at raising students' levels of achievement, identified cooperative learning, which helps students to develop their thinking and problem solving skills, as the best way of teaching. According to Moore (2005), after 24 hours, students were able to retain only 5% of lectures and just 30% of what they learned in classroom demonstrations. However, retention increased to between 75% and 90% when cooperative learning was used.

According to the National Science Education Standards (NRC, 1996), teachers may be able to achieve a number of goals when they use cooperative learning. The first goal is that of improving student thinking skills and the ability to develop their own understanding by sharing ideas with each other (Chi, Leeuw, Chiu, & LaVancher, 1994; Chin & Brown, 2000; Jones & Carter, 1998; Wood, 1992). Cooperative learning also helps teachers to advance their students' engagement with learning and students to take responsibility for their own learning, all of which harmonises with identification in the literature of a reduction in stress for teachers and a maximising of students' roles in the classroom (Chin & Brown, 2000; Jones & Carter, 1998; Kagan, 1994; Wood, 1992). Moreover, cooperative learning maximises the required communication and scientific thinking skills. It helps both teachers and students by building the social environment in which students can construct their thinking and understanding, which in turn helps their interaction with their teachers and other students (Chin & Brown, 2000; Jones & Carter, 1998; Meyer & Woodruff, 1997; Millis, 1995; Resnick & Klopfer, 1989; Wood, 1992).

According to Sharan (1980), there are five methods of cooperative learning, which can be divided into two categories: the peer tutoring method and the group investigation approach. It is suggested that the use of cooperative learning affected the students' achievement, attitude and ethnic relations.

According to Slavin (1996), "Cooperative learning has the potential to become a primary format used by the teachers to achieve both traditional and innovative goals" (p. 64).

A number of studies have suggested that the use of cooperative learning can positively affect students' achievement, self-esteem and social relationships, although more investigation might be needed into the effect of cooperative learning on these last two, (Slavin, 1996; Springer, Stanne, & Donovan, 1999).

Fernandez-Santander (2008) collected data over a four-year period, in the form of student surveys, grades and attendance. The 'lecture only' method was used in the first two years, and a combination of lectures and cooperative learning was used in the following two years. The students' attainment and satisfaction in the combination group increased more than with the lecture only method. The methods in Fernandez-Santander's study involved teachers beginning their class by presenting the main subject to the whole class, before moving on to cooperative learning in groups of two or three. This method as reported increases the students' ownership of their learning.

2.3.2 Peer tutoring

Duran (2010) gave a definition of peer tutoring, as cited in Monereo and Duran (2002):

> We shall define peer tutoring as a method of cooperative learning based on the creation of pairs of students with an asymmetrical relationship and sharing a single common goal, which is known and shared and must be achieved through a relationship framework planned by the teacher (p.3).

Peer tutoring can be defined as a well-taught strategy involving students' collaboration. It makes a link between the high- and low-achieving learners or between those with similar achievement levels. It can be used to structure the learning of reading and mathematics. A number of variations of peer tutoring can be generated, depending on "the ages within the pair and the consistency of the roles" (Duran, 2010, p.3).

There are debates on the role and importance of differences and similarities between pairs of students. Same-age and cross-age tutoring are the two most common forms of peer tutoring. Although cross-age tutoring is more commonly used in schools, same-age tutoring can be more interesting, particularly as a number of studies have indicated that the most important thing is not the age difference, but the skills difference between tutor and tutee (Duran, 2010).

In recent years there have been studies focusing on same-age and similarly-skilled pairs. In this form of peer tutoring, the 'student' and 'teacher' in a pair will then exchange roles so that each plays both parts in the exercise (Duran, 2010).

As Topping (2005) suggested, the following organisational issues need to be considered when planning peer tutoring.

1. Context: what issues might there be due to local circumstances?

2. Objectives: what is to be achieved?

3. Curriculum area: what will be taught?

4. Participants: who will be tutors and tutees? How will they be trained?

5. Helping technique: is there a specific form of tutoring to be used?

6. Contact: when, how and how frequently does tutoring occur?

7. Materials: what resources are required?

8. Training: how will staff and students be trained?

9. Process monitoring: who will monitor quality and how?

10. Assessment of students: how will students be assessed?

11. Evaluation: how will success be judged and measured?

12. Feedback: what feedback should be given and to whom?

The role of the teacher in the peer tutoring process – namely, to assist, observe, question, and direct their students' learning - is very important. However, including some whole group teaching is also important in giving the students a foundation for the lesson.

According to Fernandez-Santander (2008), “Maintaining short periods of lecturing in every session was very helpful in the development of the pupil’s trust in the new learning methodology and in the success of it” (p.38). After the teachers’ introduction, they can move to the process of peer tutoring.

2.3.3 Cooperative learning and peer tutoring: similarities and differences

Cooperative learning and peer tutoring both arise from social constructivist theories proposing that students construct their own learning in a social learning setting (Thurston et al., 2012). While cooperative learning and peer tutoring have a number of similarities, they also differ in certain respects. This section will discuss these similarities and differences.

According to Topping (2008), cooperative learning and peer tutoring are both well-structured learning methods that have a potentially significant impact on students’ learning, as has been suggested by a number of studies. Johnson and Johnson (1984) argue that successful and effective cooperative learning should include five key components. These components are the following: each individual student’s assuming responsibility for his or her own learning; face-to-face interaction among students; positive interdependence among students; students’ attainment and use of collaborative skills, and; group processing. These components can also be found in peer tutoring (Nath & Ross, 2001).

There is evidence to indicate that cooperative learning enhances students’ attainments and social skills (Lin, 2006). Further, Thurston et al. (2012) report that both cooperative learning and peer tutoring can enhance students’ attainments and social skills. Indeed, there is evidence to suggest that the use of both cooperative learning and peer tutoring enhance the value of learning, as the students can teach

each other ways to find answers, rather than giving each other the answers directly (Johnson & Johnson, 1984; Slavin, 1991). Moreover, both cooperative learning and peer tutoring stress the value of peer interaction in enhancing students' learning by involving the students in an active learning environment that gives rise to opportunities for the students to become actively involved in the learning process.

Cooperative learning reduces individuality and individual competitive behaviour and encourages students to cooperate in group activities as they learn (Cooper, 1990; Johnson et al., 1998; Joyce et al., 1987; Marzano et al., 2000; Millis, 1995; Slavin 1991; Stahl & VanSickle, 1992). In this respect, Pesci (2009) relates both cooperative learning and peer tutoring to the social interdependence theory. This theory proposes that tutor and tutee both have the same aim and work together to reach that aim. Therefore, it can be suggested that both cooperative learning and peer tutoring give rise to friendly competition between the students.

Furthermore, the role of the teacher in both cooperative learning and peer tutoring appears to be similar. Teachers should plan the learning activities to ensure that these enhance the students' metacognitive skills and make them reflect more deeply on what they learn (Pesci, 2009). However, teachers in peer tutoring have an additional role, as they have to train their students how to act as tutor and tutee in the learning process (Jenkins & Jenkins, 1987; Nath & Ross, 2001). This training is of considerable value and represents the main difference between peer tutoring and cooperative learning.

2.3.3.1 Benefits of peer tutoring

A significant number of studies have indicated that students and teachers can benefit in various ways from using peer tutoring. According to Olmscheid (1999), "The list of benefits that students receive from peer tutoring is quite extensive" (p. 3).

The effects of these benefits can be divided into four categories: the effect on students' attainment; the social effect; the effect on the students' attitude to learning and the benefit to teachers of the increase in students' engagement with learning. According to Johnson and Johnson (1994), there are five main elements leading to effective group learning, achievement, social, personal and cognitive skills such as problem solving, decision-making and planning. These are positive interdependence, individual accountability, face-to-face interaction, social skills and processing. A number of studies have indicated relationships between academic attainment and building up friendships, self-esteem and students' attitudes (Eccles et al., 1999; Masten et al., 1995; Parker et al., 1995).

First, the studies showed that students can benefit academically from peer tutoring. According to Topping (2005), "The research evidence is clear that both peer tutoring and cooperative learning can yield significant gains in academic achievement in the targeted curriculum area" (p. 635).

Topping (2005) asserted that one such gain is a deep understanding of the curriculum content. In a study examining the performance in mathematics of two groups at elementary level, one of which employed peer tutoring in their learning while the other did not, Harris and Sherman (1973) found that "the tutored students received better grades at the end of an academic quarter than did students in a matched control group who received no tutoring" (p. 588).

In a meta-analysis of 38 studies from 1972 to 2002 on students with emotional or behavioural disorders, Spencer (2006) concluded that in all of the 38 studies, peer tutoring was shown to be an effective learning strategy. The most effective form of peer tutoring was when the students exchanged the roles of tutor and tutee repeatedly. However, it was found that the tutor students were at a greater advantage than the tutee students as they gained a deeper understanding of the subjects being learned when the roles were not exchanged repeatedly.

In an action study by Mesler (2009), retained third-grade students (i.e., those repeating a year) were paired with struggling peers. Both tutor and tutee students showed significant gains in their test scores at the end of the academic year, the improvement resulting from the retained students' gaining confidence and the extra maths practice they had had.

Pigott et al. (1986) examined the effect of peer tutoring at the fifth level (aged from 10 to 12 years old), and found that peer tutoring enhanced the students' attainment. In this study each group of four students was assigned to a separate role during an arithmetic exercise. In a similar study by Kamps et al. (1994), investigating student attainment in reading comprehension and fluency, students engaged in peer tutoring demonstrated increased understanding. Vincent (1999) asserted that "Decades of research have established that well-planned peer tutoring programs can improve student achievement and self-esteem as well as overall school climate" (P. 8).

Tymms et al. (2011) carried out a study over two years involving 129 primary schools in Scotland with students aged eight or ten. In this study students' attainment in reading and mathematics was positively affected by the use of cross-age peer tutoring.

The second category is the social effect of using peer tutoring. There is evidence that peer tutoring can positively affect students' social and behavioural skills and that awareness of the social situation can affect the outcomes. In a meta-analysis by Roseth et al. (2006) that comprised 148 separate studies from 11different countries, academic achievement was strongly related to interpersonal perception for middle-grade students (aged 10 to 14 years). According to Topping (2005), "Peer learning encourages personal and social development" (p. 643), while Fitz-Gibbon (1988) stated that students who learn through peer tutoring, whether they are tutoring or being tutored, work together and communicate effectively with each other. Peer tutoring can help to improve students' communication skills as they have to explain ideas and concepts to each other in their own words (Topping, 2005). Students use a number of valuable communication skills when peer tutoring such as listening, explaining, questioning, summarising, speculating and hypothesising (Topping, 2005). Miller, Topping, and Thurston (2010) and Topping (2005) are among a number of psychologists who discussed the increase in students' self-esteem attributed to peer tutoring. Ginsburg-Block et al. (2006) also found, in a meta-analysis of 36 studies of peer learning in elementary schools, that there was positive correlation between social and self-perceptive outcomes and academic outcomes (Pearson's $r=0.50$, $n=20$, $p<0.01$). In a study involving nine- to twelve-year-olds in 24 Scottish primary schools, Tolmie et al. (2010) demonstrated an increase in the marks achieved in both cognitive science tests and social relationships when collaborative learning was used, while a study of 5^{th} and 6^{th} grade students (aged 10 to 12) in schools in the American mid-west identified an increase in both academic and social gains when cooperative learning was used in science lessons (Johnson et al., 1985). Roseth et al., (2009), in a meta-analysis study involving 17,000 students from 148 studies, not only found positive increases in students' achievements (ES=0.46) and improved social relationships (ES=0.48) with cooperative learning as well as individual learning, but also that there were significant correlations between peer attraction and achievement outcomes. Students achieved higher scores and had better social relationships when learning cooperatively.

As Roseth et al. (2009) noted, "… positive social relationships increase promotive interaction, which increases achievement, which increases positive cathexis, which increases positive social relationships even more, and so forth" (p. 226).

Empirical studies have suggested direct and indirect relationships between social relationship and academic achievement outcomes when peer learning methodologies were applied in the learning process (DiPerna, Volpe, Elliott, 2001; Zins, Bloodworth, Weissberg, & Walberg, 2004). Similarly, Allen et al. (2012) observed that

> a limitation of the current literature in respect of social relationships on outcomes is that many studies do not establish whether good relationships are a pre-condition for achievement, a related consequence of achievement or a separate outcome than achievement (p. 4).

The third category is the effect of peer tutoring on students' attitude towards learning. Topping (2005) observed that peer tutoring can result in students being more attracted and receptive to the subject being studied, stating that "Affective changes in attitude to school, the teacher, the subject, peers, and to the self might also be found" (p. 641).

The fourth category is the advantage of peer tutoring in increasing students' engagement with learning, since every learner participates significantly and effectively in the learning process (Philips & Soltis, 2004). In general, the educator's role is to assist the class during discourse, and arrange the learning environment (Brophy, 2002).

According to Price (2006), teachers are responsible for creating a suitable classroom environment for creative lessons. Furthermore, large numbers of studies support the idea that peer tutoring helps students to engage more with learning and teachers to build an active learning environment that, in its turn, helps students so to engage. As Olmscheid (1999) concluded, "By utilizing peer tutoring in the classroom, teachers will ideally be able to teach more effectively" (p. 5).

Greenwood (1991) and Olmscheid (1999) also found that peer tutoring can help students to increase their engagement in the classroom academically. “Peer tutoring gives teachers the opportunity to maximize their instructional influence on the classroom as well as to provide individualized instruction” (Kourea, Cartledge, Musti-Rao, 2007, p. 106).

Rosewal et al. (1995) conducted a study comparing the changes of self-concept with the student’s probability of dropping out of school. The students participating in the study were divided into two groups, only one of which was in a peer tutoring programme. A significant increase in self-concept and general attitude towards school was noted for the students participating in a peer tutoring programme compared to those being taught by more traditional methods.

Walker (2007) concluded that students who had participated in a peer tutoring programme or cooperative learning forms had a higher self-concept and greater satisfaction than students involved in more traditional forms of individual and isolated learning.

A two-year Randomized Control Trial (RCT) undertaken by Topping et al. (2011), involving 86 co-educational and mixed-ability Scottish primary schools of average socioeconomic status, suggested a significant gain in mathematical achievement for cross age tutoring over both years. In the same study, other differences were not significant. The study also found, through micro-evaluation, an improvement in selected schools in Year 1. However, there was significant progress in both Year 2 mathematics-only groups and for less able students, from randomly selected schools.

In a meta-analysis of RCTs on the educational outcomes of tutoring by Cohen, Kulik & Kulik (1982), the average effect size (ES) in the 52 studies was 0.40 and the standard error of ES was 0.069. In addition, the average ES of the students’ attitude towards subject matter was 0.29 with the standard error of 0.08. It was also found that the tutoring programs affect positively the tutored students' attitudes to the subject being taught. Moreover, the average ES of achievement in 38 studies was 0.33 and the standard error was 0.09, while the average ES of the attitude to the subject being taught was 0.42 with a standard error of 0.46.

In a meta-analysis of RCTs on peer tutoring by Cook et al. (1986), 19 studies yielded 74 ESs and, in common with many other studies, the study indicated that the peer tutoring programmes in general positively affect students, with the tutees gaining more than the tutors. The improvement ratings for both tutor and tutee on self-concept and sociometry were smaller than those for attitude.

2.3.3.2 Justification for choice of same-age peer tutoring rather than cross-age peer tutoring

According to Thurston (2013),

> Some projects have tutors and tutees of the same age, and some have older children as the tutors. If the tutors and tutees are not too far apart in age and ability, there may be even more chance of the tutor gaining as a result. Some schools are also now tutoring with pairs of the same ability, where the job of tutor switches from one to the other. This form of tutoring seems to have the best effects overall as both children get the boost to confidence and status benefit of acting as tutor and tutee (p.6).

Hence, the mutual process in this method improves the ability of both of the pairs to take advantage of the learning process, which increases the students’ engagement in the learning process and gives them the impression of playing an important role in the learning process.

In addition, in this present study, same ability matching allowed the researcher to suggest an effective method of learning for the class to assist in minimising the teaching changes in order for them to be acceptable to the teachers who had never been involved in research and had been never asked to change their teaching methods. It was important to minimise these changes to ensure the teachers' willingness to make these changes in their teaching methods.

Thus, there is considerable evidence to support the contention that peer tutoring is an effective method of enhancing various elements of students' learning. Among these elements are learning attainment, social skills, engagement in learning, metacognitive skills, and self esteem. There is evidence to show that there is a need to enhance these elements, in particular learning attainment, in education in Saudi Arabia, as mentioned in the introduction to this thesis. Therefore, it is suggested that peer tutoring would be effective in enhancing these elements of learning in Saudi Arabian schools. However, it is necessary to conduct research in order to establish whether this would indeed be the case.

2.4 Theories on the learning of mathematics

This thesis aims to research, pilot, test and develop mathematical pedagogies to improve attainment in schools in Saudi Arabia. Mathematics is a unique subject and many studies have been conducted to develop theories on the learning of this subject. Therefore, it is essential to examine some of these theories, as it is important to link these theories with general learning theories.

Frobisher (1999) concluded the Scottish Guidelines (SOED, 1999) by stating that mathematics was perceived in the following ways:

> A body of collected knowledge and procedures for working with patterns and relationships in number and space.
>
> A powerful, concise and unambiguous way of organising, manipulating and communicating information.
>
> A means by which aspects of the physical and social world can be explained and predicted.
>
> An activity involving processes such as discovering, discussing, ordering, classifying, generalising, drawing and measuring.
>
> A source of challenge, satisfaction and pleasure (as cited in Frobisher, 1999, p. viii).

According to Haylock and Thangata (2007), there are five categories into which the teaching of mathematics can be divided.

The first category is utilitarian, in which students use mathematics to deal with the problems of everyday life; numeracy is the most useful mathematical element here. The second category is application, whereby students are helped to deal with issues they might face in other subjects, such as physics and chemistry, and develop their knowledge and skills to the necessary level for understanding mathematics. The third category relates to developmental thinking; that is, students develop their thinking skills, very commonly through problem-solving, for which they should also aim to think in abstract terms. The fourth category is aesthetic, in which the aim is to guide students to appreciate the beauty of mathematics, and to enjoy learning it as much as they enjoy other subjects. The fifth category is epistemological. Mathematics can be described as one of the most important fields of education for any society that calls itself civilised, related as it is to many of the sciences (Haylock and Thangata, 2007).

These categories demonstrate how important it is to teach and learn mathematics in our schools.

In teaching mathematics, teaching both for competent calculation and for understanding is needed. They are interdependent: when teaching for competent calculating, understanding is needed and when teaching for understanding, competent calculating skills are needed. Using both of these can help students to solve the real mathematical problems with which they might be faced.

According to Liebeck (1984), there are six questions on the why and how of learning mathematics.

The first one is, 'Why teach mathematics?' It is well known that mathematics as a science is a powerful and important tool at every level of our daily lives. The second is, 'Why do people enjoy mathematics?' Although mathematics seem to be boring for a number of people, a great number of others enjoy it, just as much as others who enjoy learning about music and other arts.

The third question is, 'How can mathematics appeal to one aesthetically, in a way similar to music or art?' In the same way that people enjoy music or art in different ways, they can enjoy the different elements of mathematics. Some can enjoy algebra, others can enjoy other branches of mathematics.

The fourth question is, 'Mathematics is often called an abstract subject. What is meant by this?' It is clear that most mathematical ideas are hard to explain unless they are explained physically as a first step. Many people, particularly very young children for example, cannot understand what '3' means, or 'the threeness of three' as it is sometimes described, without repeatedly being shown and able to handle one, two and three objects.

The fifth question is, 'How does the brain cope with this hierarchy? When one sees the symbol '143', one does not imagine one hundred and forty-three objects set out before one. Has one then lost contact with the real world?' The answer is no. The reality in such an example must be understood through the system of notation. One should imagine three groups of singles, four groups of ten and one group of one hundred.

Finally, 'How does a child develop abstract thought?' The child needs four steps in order to do this, namely experience with physical objects; spoken language that describes that experience; pictures that represent the experience, and; written symbols that generalize the experience.

According to Thyer and Maggs (1991), the role of teachers is significant in teaching mathematics as children's ability to discover mathematics through their environment is limited, and they develop their understanding of concept from practice to the theory level using language, which makes the teacher's role very important.

Teachers are the key to success in the teaching of mathematics. Children learn through involvement in practical activities that they undertake themselves. The lack of both the undertaking and the supervision of such activities can be harmful to their understanding of mathematics. Initially, students should be given the chance for free play before a situation is set up and explained. Thereafter there could be discussion in order to encourage the students to express their opinions on the issue.

Price (2006) averred that teachers are responsible for creating a suitable environment for creative lessons in the classroom, necessitating skills which they are developing increasingly. Although following creative methods in teaching mathematics can be regarded as risky in terms of student understanding, the results so far are mostly positive. All that is needed is for the teacher to focus on them. It is also important that although teachers need to be knowledgeable about what they teach, high quality teaching skills are more necessary than knowledge. Students should be involved in practical activities and given opportunities to explain their thinking about what they are doing. This might help teachers to reflect on the students' knowledge.

Piaget (1950) made an interesting observation on the importance of language in teaching mathematics: every single action, symbol and equation can be described verbally. The symbols are just shortened words and sentences, and the quality of verbal interaction between children as learners and their teachers is highly important and can make all the difference (Piaget, 1950).

Mathematics, like other sciences, has been affected by educational theories and psychological concepts. Returning to Piaget's theory of cognitive development, it is clear that mathematical ideas should be explained using practical, physical resources with students studying at primary school. It is apparent that this is the best way to teach primary school students, as these students are in the second and third stages of the cognitive development structure.

The theory of experiential education supports the idea that learning improves when learners are involved in active learning processes (Hartshorn & Boren, 1990). Manipulatives can provide an active environment or can be the key to building one. Manipulatives help students progress from an abstract to a concrete level of learning and using them might help students to improve their mathematical thinking and understanding skills. The long-term use of manipulatives is supportive in other ways, such as assisting students with verbal thinking, helping them discuss mathematical ideas easily and effectively, improving students' abilities to transfer real life problems into mathematical problems, providing them with opportunities to improve their social skills, enabling them to increase their confidence when, for example, making presentations and expressing ideas (Hartshorn & Boren, 1990).

Social constructivism, as shown above, is an approach that explains learning as a social process. This means that students construct their knowledge socially, learning from each other. In this approach, social activities have valuable roles: each person can simultaneously be a student and a teacher. All students have individually important roles in the learning process (Philips & Soltis, 2004). Students benefit each other during the learning process and manipulatives work to make this benefit transfer friendly (Berk, 1999).

This social constructivist activity can be noted from the role of both students and teachers in the classroom. The teacher’s role in general is to assist in the classroom during the lesson and prepare the learning environment appropriately, including setting out classroom materials and arranging the overall layout.

On the other hand, teachers might use manipulatives in a behaviourist way. Traditionally, teachers initially use manipulatives to introduce an idea and then they ask their students to imitate the process. This method might be risky, particularly if teachers are not knowledgeable as to how to use concrete materials (Moscardini, 2009), and might mean they expect students to use them individually rather than cooperatively and socially. Moscardini (2009) stated that although students use different materials to make sense of what they learn, teachers use materials as a way of putting into practice the ideas they express.

This mode of using materials, including manipulatives, can be seen as an echo of classical conditioning. That is, teachers introduce a new mathematical idea to students and then give them time to practise this idea using manipulatives. Although this way of using manipulatives helps behaviourist teachers, it conflicts with the current widespread support for social constructivism. Using manipulatives in a behaviourist way can harmonise the role of educators and the nature of learners, as Philips and Soltis (2004), Kimball and Heron (1988), and Ormrod (2004) have stated. Learners are passive, as they respond to specific stimuli (Philips & Soltis, 2004). Behaviourism also asserts that nature and the environment can clarify and explain human behaviour. Moreover, behaviourists believe that learners act as intermediaries between behaviour and the environment, as is evidenced by the assumption that behaviours are controlled by their environment and that the environment plays the role of writing on learners' brains, which are like blank slates (Ormrod, 2004). The educator's role is to provide text and supervision, and to give learners feedback during the learning process (Kimball & Heron, 1988).

In the researcher's experience, the use of manipulatives is rare in Saudi Arabia. Further, when they are used, they are given to students to use individually rather than in pairs or groups. Hence, the students remain passive learners and do not engage or interact in the learning process.

Frobisher (1999) explained learning as a social process in which teachers share their knowledge and experiences with their students and students share them with each other. Moreover, although more is now known about how children learn mathematics, less effort has been made to explain the best way of teaching it to them. Effective mathematics teachers are those who can guide their students to a good attitude and develop their fullest potential for their future learning. The teaching environment should be one of active learning that can help each student to be a valuable asset in the classroom.

Frobisher (1999) has identified a number of manipulatives that can be used to introduce and explain mathematical ideas and concepts. These manipulatives can help teachers to build a social environment of which students can take advantage to share their knowledge and experiences with each other. In other words, there should be a combination of the use of manipulatives and the social constructivist strategies. As discussed previously, a number of social constructivist strategies, including working in small groups, group discussion, peer learning and cooperative learning have been identified in research studies. Although there is agreement that the theoretical implications of social constructivism can be advantageous to students and enhance their learning, there are also arguments about the most successful method or strategy for reaching the highest level of achievement in the classroom. In short, greater attention should be paid to identifying the best way of using manipulatives in relation to the theories of social constructivism, as there are agreements as to the way in which manipulatives can be used to the advantage of both teachers and students in the classroom.

2.4.1 Problem solving and manipulatives

The use of manipulatives has affected the theories of problem solving. A number of studies have examined the usefulness of using concrete materials in teaching mathematics relating to problem-solving theory.

A study by Ainsa (1999) revealed results regarding problem-solving skills and the use of manipulatives, confirming that manipulatives helped teachers improve their students' problem-solving abilities. Furthermore, Ainsa (1999) showed that children appeared to find learning more fun when using manipulatives.

Clements (2000) also stated that using manipulatives in teaching mathematics helps students improve their problem-solving abilities, noting a significant increase in students' scores in both problem-solving and retention tests when manipulatives were used in mathematics teaching and learning processes. Kelly (2006) supported this, stating that the use of manipulatives could help make the problem-solving process easier and can similarly improve students' skills. However, their understanding must be examined throughout the teaching process. The process of examining students' understanding and therefore progress in problem-solving can be helpful in choosing the best manipulative for each occasion.

Baroody (1989), however, argues that using manipulatives in teaching mathematics cannot guarantee success. Other methods, such as peer tutoring, must also be employed when teachers use mathematical manipulatives. A study by Fennema (1972) showed that classes that did not use manipulatives performed better in exams than ones that did use them during a transfer test. According to Clements (2000), "although research might suggest that instruction begins 'concretely,' it also warns that manipulatives are not sufficient to guarantee meaningful learning" (p. 46).

The above statements agree that although manipulatives are important, other issues must be taken into account. Returning to the role of teachers and the nature of learners in the classrooms, as stated in various learning theories, the importance of the teacher's role can be seen in terms of achieving the greatest benefit from using manipulatives, as well as the importance of teachers being constantly aware of the way in which they are using them. Moscardini (2009) suggested that although students with difficulties in understanding achieve meaningful learning when their teachers use hands-on materials, teachers should be more aware of their purpose in using these materials, particularly as it affects their teaching. It is a challenge for teachers to become more aware of their students' mathematical thinking skills in order to develop suitable teaching environments.

Teachers without a strong understanding of the most effective way of using manipulatives in the classroom may still be in need of support or training in this area. They should have a clear idea of the importance of the different ways in which they use manipulatives to reach their goals and make mathematical problem-solving easier. Moreover, the way students use manipulatives should take note of recommendations drawn from theories of learning in order to help them gain the greatest benefit from their use. Learners must be actively involved in their learning in order to construct their knowledge and obtain more information effectively, rather than being receptive learners constructing their knowledge through others. Learners build their own meanings (Poplin, 1988) and, as Piaget believes, build their knowledge step-by-step by being involved in active learning processes, all of which correlates with what Philips and Soltis (2004) suggested were the roles of learners in the learning processes.

2.4.2 The usefulness of manipulatives in mathematics teaching

Several researchers and authorities agreed that using manipulatives is helpful, including, for example, the National Council of Teachers of Mathematics (NCTM) and (Schweyer, 2000; Berk, 1999; Moch, 2001; Rust, 1999; Moyer, 2001; Stein & Bovalino, 2001; Kosko & Wilkins, 2010). Although these researchers agreed on the usefulness of manipulatives in mathematics teaching and learning, they differed as to the best way of using manipulatives to reach meaningful understanding. This section will highlight the usefulness of manipulatives in mathematics teaching.

Berk (1999) stated that using mathematical manipulatives is one of the best ways of presenting concepts on an abstract level. Manipulatives can establish a solid foundation of concepts. Using them provides students with a greater opportunity of gaining a deep and effective understanding of concepts (Schweyer, 2000). In addition, Moch (2001) stated that the interest level of students of both genders who were previously uninterested in mathematics increases when manipulatives are involved in teaching, and their excitement about learning mathematical concepts increased during activities involving manipulatives. This study showed that the use of manipulatives in teaching mathematics positively influenced students' achievements. Students were keen to discover new mathematical ideas and concepts through these activities.

According to the same study,

> If using manipulatives for only 18 hours over a seven-week period increases scores by an average of 10 percent, what could gains be for these same students in a stable environment using manipulatives for the entire school year? Of course this is speculation, but the findings of this study suggest that gains would be significant and rewarding for students as well as instructors (p.86, 87).

Rust (1999) recommended a different style of teaching from the traditional, more passive one, since students can actively help each other understand mathematics in various ways, and observed that students seemed to enjoy learning when manipulatives were involved.

Krontiris-Litowitz used an experimental method (2003) involving modelling clay and beads as manipulatives and found an improvement in the quality of student performance in a neurobiology class. The study also found improvements in conceptual understanding, dismantling misconceptions, and critical thinking. Although there were students who were inactive during the teaching activity, they showed improvement during quizzes.

Shaw (2002) went further, stating that mathematical manipulatives are helpful and worthwhile even when only pictures of them are used and the effectiveness of the long-term use of manipulatives was also noted.

According to Shaw (2002),

> When small or large learning groups explore new ideas or explain understandings, they have something to talk about when they have manipulatives and models to work with. Discussions and learning become more focused. Multisensory experiences provide access to ideas and concepts, and offer multiple entry points in discussions and reasoning, ensuring that all students in the group are active participants (p.3).

This idea was challenged by a number of studies which claimed that there are other steps that should be taken in order to gain such benefits (Moscardini, 2008; Baroody, 1989; Kelly, 2006).

Kelly (2006) suggested the following ten steps to help teachers make effective use of manipulatives in performance-based tasks.

1. Clearly set and maintain behaviour standards for manipulatives.
2. Clearly state and set the purpose of the manipulative within the mathematics lesson.
3. Facilitate cooperative and partner work to enhance mathematics language development.
4. Allow students an introductory timeframe for free exploration.
5. Model manipulatives clearly and often.
6. Incorporate a variety of ways to use each manipulative.
7. Support and respect manipulative use by all students.
8. Make manipulatives available and accessible.
9. Support risk-taking and inventiveness in both students and colleagues.
10. Establish a performance-based assessment process (pp.189, 190).

Although the above studies showed that using manipulatives in mathematics teaching creates positive results, there are other researchers who disagree with this idea on the grounds that manipulatives are useful even if only some of the factors are taken into account. For example, Clements (2000) proposed that although manipulatives can play a useful role in teaching mathematics, both teachers and students should be aware of how they are using manipulatives, which should be for specific purposes, and in a social way:

> Manipulatives can play a role in students' construction of meaningful ideas. They should be used before formal symbolic instruction, such as teaching algorithms. However, other common perspectives on using manipulatives should be re-considered. Teachers and students should avoid using manipulatives as an end – without careful thought – rather than as a means to that end. A manipulative's physical nature does not carry the meaning of a mathematical idea. Manipulatives alone are not sufficient – they must be used in the context of educational tasks to actively engage children's thinking with teacher guidance. In addition, definitions of what constitute a 'manipulative' may need to be expanded to include computer manipulatives, which, at certain phases of learning, may be more efficacious than their physical counterparts (p.56).

Perry, Howard and Tracey (1999) found that it was necessary to train mathematics teachers in how to use mathematical manipulatives. This training should take place at both at college during their initial training and at improvement level, as in-service training (INSET). Mathematics teachers should accept the idea that it is to their students' advantage to use manipulatives as teaching aids. The same study recorded that although teachers may appear confident in the use of manipulatives, they state that they would appreciate more training in how to use them effectively.

These disagreements between researchers who think manipulatives can give positive results simply by virtue of being used and others who disagree, lead to a number of questions that must be addressed. Teachers' attitudes should be examined in order to resolve these disagreements and issues.

The studies suggested that manipulatives should be used in teaching mathematics to increase and enhance students' subject-related communication and conversation skills.

Verbal communication is axiomatic when using manipulatives in learning mathematics (Moch, 2001), while Cramer & Karnowski (1995) found a connection between the use of manipulatives and an improvement in students' communication.

Kosko and Wilkins (2010) conducted an empirical study on fifth grade students (aged 10 and 11 years old) in the USA. The study used data taken from the Early Childhood Longitudinal Study which comprised 11,820 fifth grade students around the USA, a sub-sample of which (N=4,922) was included in this study. Mathematics teachers who participated in that study completed a questionnaire for every individual student relating to classroom practice and information. The study suggested that a statistically positive relationship exists between manipulative use and communication in mathematics. The correlations were observed between manipulative use and both writing ($p=.32$) and discussion ($p=.32$).

Cramer and Karnowski (1995) describe the manipulatives as interacting between two types of symbol, such as real-life situations, pictures, verbal and written symbols. However, they did not provide or support evidence of any such relationship.

The link between manipulatives and communication was discussed in the methods of other studies. Moyer (2001) conducted a study on teachers who use manipulatives in teaching mathematics. The discussion among the students was a part of the use of manipulatives. Moyer’s study aimed to examine the reasons for, and the ways of, using manipulatives by middle school teachers. One of the studies focuses on classroom discussion; students’ interactions, leading to conversations, were highlighted as among the most important factors in the way students used manipulatives, and improved interpersonal communication as one of the most positive effects. The study showed that students’ communication was one of the positive effects of using manipulatives; however, the study showed that although teachers directed the use of manipulatives and conversations, they did not appear to put as much emphasis on conversations as was suggested by the use of manipulatives.

Moch’s (2001) study, discussed earlier, on the effects of using manipulatives in improving skills in different mathematics subjects, stressed that the students’ test scores improved by ten percent, although the manipulatives were used for just 18 hours over seven weeks. The study mentioned that teachers used several teaching strategies that seemed to be effective, including discussions and discourses. However, the study did not mention the amount of discourse included when manipulatives were used.

Stein and Bovalino (2001) included discourse between the students as one type of necessary activity when using manipulatives, another being writing. The aim of their study was to present examples of effective ways of using manipulatives.

Both *Mathematics Assessment: A Practical Handbook for Grades 6-8* (NCTM, 2000) and *Literacy Strategies for Improving Mathematics Instruction* (Kenney, 2005) linked the use of manipulatives with communication.

The studies clearly recognise the value both of students' communication in learning mathematics and the role of manipulatives in developing these skills.

The use of manipulatives alone appears to be insufficient to enhance learning skills, in particular in the way in which Saudi teachers use them. As mentioned previously, on the rare occasions where manipulatives are used in Saudi Arabia, they are not used in such a way as to encourage communication. Although there is evidence to show that the use of manipulatives can enhance students' learning, it has been argued that other elements must be used in conjunction with them in order for them to be effective.

2.4.3 Issues related to the use of manipulatives

Clements (2000) stressed that the effective use of manipulatives requires reflective teachers who can make the most of them in order to make mathematical ideas more understandable and meaningful. Therefore, mathematics teachers should be aware of the purpose of using manipulatives, as relating to their beliefs in particular learning theories, and take account of the way in which they are actually using them. Stein and Bovalino (2001) supported this view, emphasising that good and effective learning using manipulatives cannot be guaranteed unless encouraged by a reflective teacher with the ability to use them effectively. The above studies clearly show how difficult it is to benefit from using manipulatives and how important knowledgeable and reflective teachers are in the learning process. Understanding the importance of these essential roles, which place teachers at the centre of a number of studies on manipulatives and manipulatives material, helps to identify teachers' attitudes to manipulatives.

In sum, it has been shown that the use of manipulatives can enhance learning, but is most effective when combined with another element, such as peer tutoring. Similarly, peer tutoring has been shown to enhance learning, and is particularly effective when used in conjunction with materials such as manipulatives. In this light, the following section reviews the extant literature on the use of peer tutoring and manipulatives together in learning mathematics.

2.5 Combining the use of peer tutoring and manipulatives in learning mathematics in the literature

It is suggested that materials such as manipulatives should be used together with peer tutoring in learning mathematics.

According to Barley et al. (2002), successful peer tutoring in learning mathematics usually includes three main elements, namely, training the students to be prepared to act as tutors and tutees so they understand the process of peer tutoring, involving well-structured activities in which the students can interact socially, and using materials such as manipulatives. Students should act sometimes as tutor and sometimes as tutee, thereby, very importantly, training them to understand the process of the two roles. Well-structured activities are important in any successful peer tutoring; therefore, teachers should plan their lessons and be prepared with the necessary materials for the lesson. Given the importance of involving materials such as manipulatives in increasing the advantages of peer tutoring in mathematics, it is suggested that teachers should provide these manipulatives when they use peer tutoring.

Although the use of materials with peer tutoring in learning mathematics was suggested in the literature, some did not make clear either which kind of materials teachers should be presented to their students or the way in which these materials should be used. Few studies mentioned manipulatives as the materials that should be used together with peer tutoring in learning mathematics.

Barone and Taylor (1996), in a field study at Fulton Elementary School in Aurora in the USA, involving 440 mixed-ethnicity students, suggested that teachers should be required to prepare manipulatives and train their students to teach each other when they use peer tutoring. The results of this study suggested that the students' self-esteem, sense of responsibility, skills, motivation, academic attainment, awareness of the needs of others and appreciation of teachers all improved significantly when they learned mathematics using peer tutoring and manipulatives together, and that teachers were positively stimulated by that improvement.

Pickett (2011) carried out an action research study involving one fourth-grade mixed-ethnicity classroom of twenty students (ten male and ten female) in Hunter Street Elementary School in York, South Carolina. The study examined the effect of using peer tutoring on the students' achievement and Pickett (2011) suggested adding the use of manipulatives to the peer tutoring. Students' achievements, attitudes towards mathematics and attitudes towards their learning partners showed statistical improvement after the intervention.

Thus, the research studies show clearly that there is a relationship between the increase in communication between students and the improvement in their learning of mathematics using peer tutoring.

On the other hand, the use of manipulatives was also reported to increase students' communications, which in turn enhanced their learning of mathematics (NCTM, 2000; Shaw, 2002). Therefore, it is suggested that using manipulatives with a social learning strategy maximises the benefits of using both. As mentioned in the literature, the use of manipulatives cannot guarantee that students will benefit by their use, if they are not used in an appropriate way.

In conclusion, it is suggested that manipulatives should be used in a social learning strategy and that peer tutoring in learning mathematics should involve the use of manipulatives. While using both manipulatives and peer tutoring on their own was reported to enhance the students' communications, and therefore their learning, the literature on using a combination of peer tutoring with manipulatives in learning mathematics is limited.

Studies examining the use of peer tutoring suggest the use of manipulatives, and make proposals as to how they should be used in a social manner. However, the literature does not explain which is of greater value - the use of peer tutoring or the use of manipulatives, or whether combining them affects students' learning of mathematics positively or negatively. This present study is therefore the first to examine the effects and the results of using peer tutoring and manipulatives, both separately and together, in learning mathematics.

2.6 Education policy in Saudi Arabia

2.6.1 Background to the change in education policy

A policy can be defined as an action undertaken for the purpose of making further decisions in order to gain a tangible objective (Birkland, 2001). There are differences between a policy and a law. A law is a formulation of prohibitions or facilitations of certain acts, while a policy can be defined as a guideline to help gain a specific end by using specific resources and tools (McCool & Daniel, 1995).

A policy can be developed for either general or specific purposes: general purposes include the economy or education, and specific purposes might focus on child labour or female emancipation (Dye, 1976). This means that policies may be understood as mechanisms for achieving stated aims in political, management, financial and administrative fields. Commonly, government policy can be detected in its legislation, regulations and programmes, which may be termed instruments of policy. Education policy can be defined as a guideline or set of guidelines that helps the institution responsible to control the methodologies and mechanisms used to achieve goals set in the light of a greater purpose. Education policies usually follow a pre-set time scale (Bridgman & Davis, 2004). The government usually issues education policies after a process of evaluating the actions of past governments. New targets are set and necessary budgets allocated accordingly. People are the main source of judgment of government performance. People's perspectives depend on the outcome of the policy, and the decision to follow or reject it is made afterwards.

Education policy should cover all possible related issues, such as the best use of time and the appropriate preparation of suitable learning space (McIntosh, 2005), both of which are serious steps towards improving educational performance. Education policy should be analysed and observed by scholars and researchers in order to address the purpose of education, including identifying objectives and the means of attaining them. Research studies can give education policy more authenticity for application in various institutions.

In order to develop policy, research, analysis, consultation and synthesis of information should be undertaken and recommendations produced (Singh, 1972, p. 7), which can be used to manage the education process. Therefore, the development of education policy can be helpful for education management.

Although the use of RCTs is unusual in educational studies (Topping et al., 2011), the results of this kind of study are considered to be evidence of the highest grade. Tymms et al. (2011) suggested that RCTs can be helpful in the creation of educational policy at the highest level and are highly recommended when making or developing such a policy.

A number of benefits may be gained by applying RCTs to educational research, one of which is that given the advantages of scale, their use may yield highly reliable evidence that can be accepted as authoritative by policy makers. It is difficult to produce significant results from very small-scale studies. According to Hutchison and Styles (2010), a situation repeatedly arises with educational interventions, whereby an untested intervention is accepted by policy makers who subsequently and belatedly recognise that this new intervention should be properly tested and evidence produced, examined and evaluated to indicate whether or not it is effective. Unfortunately, the evaluation of new interventions usually takes place after they are already widely in use. Hutchison and Styles (2010) suggested that by applying RCT to the above, such a situation should not arise. In order to discover if an intervention works or not, RCT should be considered as the primary method to use (Hutchison & Styles, 2010).

2.6.2 Education policy makers in Saudi Arabia

There are three agencies responsible for educational policy in Saudi Arabia, namely the Ministry of Education, the Ministry of Higher Education and the General Organisation for Technical Education and Vocational Training. A fourth agency, the General Presidency of Girls' Education, which became part of the Ministry of Education and was itself established in 1953 to replace the Directorate of Education. The General Presidency of Girls' Education was organised in 1960 to take responsibility for girls' education and design an appropriate curriculum for girls within the requirements of Saudi culture and society. In 2002, the General Presidency of Girls' Education was absorbed into the Ministry of Education. The Ministry of Higher Education was established in 1975 to supervise all related areas of higher education such as universities and colleges, and to assume responsibility for Saudi Arabian scholarship programmes. The General Organization for Technical Education and Vocational Training was established in 1980 in order to supervise the increasing technical support needed for specialised technical training.

2.7 Conducting RCTs: the specifications and challenges

Although the results of RCTs are considered to be evidence of the highest order (Tymms et. al., 2011), conducting RCT researches is unusual in educational studies (Topping et al., 2011). Tymms et al. (2011) suggested that the use of RCTs can be helpful in influencing the creation of educational policy at the highest level, and is highly recommended in developing such policy.

2.7.1 Principles of RCTs

2.7.1.1 Randomisation allocations (what, how, why)

Random allocation is a method that ensures an equal chance for participants to be allocated into the study groups. In RCTs the allocation should be random. No participants, including those undertaking and performing the intervention, should know to which study groups they will be assigned until the start of the intervention (Torgerson & Torgerson, 2013). Randomised allocation must take place after participants' agreement to take part in the study (Torgerson & Torgerson, 2013), and since it gives participants equal chances to be allocated into the study groups, is the best way to avoid allocation bias (Torgerson & Torgerson, 2013). High-quality randomised experiments are important in establishing evidence of the effectiveness of a research study (Slavin, 2008).

The better the randomisation is carried out, the better its purpose is achieved. The aim of random allocation is a reduction in the chance of either selection bias or allocation bias, which increases the power of the statistics (Torgerson & Torgerson, 2013; Slavin, 2008). In general, even group sizes can lead to an increase in statistical power, although this is not always the case, as uneven group sizes can sometimes be even more influential than even group sizes. A sound randomisation procedure should avoid selection bias (Torgerson & Torgerson, 2013; Slavin, 2008). Although researchers might be in a situation where selection bias is inevitable, this is considered to be a limitation, since the basic characteristics, risk factors and confounders cannot be balanced between the groups.

2.7.1.2 Sample size (overpowered or underpowered)

Counting the sample size required for the study is the best way to insure that the sample size is not overpowered or underpowered. RCTs in educational studies tend to be small, which can affect the statistical results significantly (Torgerson & Torgerson, 2013; Slavin, 2008). A sample size that is too large is a waste of resources, which can be considered unethical, while too small a sample size can lead to a large effect size (Slavin, 2008). The sampling distribution for the sample which is too small is wider than the sampling distribution for the larger sample size. In the other words, the more reasonable the sample size is, the greater the validity of the study result.

2.7.1.3 Designing an RCT (steps to be taken into account)

Torgerson and Torgerson (2013) suggested steps that should be taken for a well-designed RCT, namely

> register trial protocol; identify and recruit schools; identify and recruit children; pre-test children (optional); randomise schools to two or more groups (independent third party); implement intervention; test children under exam conditions; mark tests (markers to be independent, and masked or blinded); analyse test results (accounting for clustering) and report and publish trial results according to CONSORT criteria (p. 5).

Applying the above steps can help the researcher to maximise the benefits of conducting an RCT although there may be situations in which the researcher cannot include all these steps.

2.7.1.4 Ethical issues involved in the use of RCTs

Ethical principles in research studies are concerned with ensuring the rights of participants. According to Hammersley and Traianou (2012), there are five ethical principles. The first is minimising harm. It is important for the researcher to be aware of whether any harm will result from undertaking the research, and, if so, the impact of this harm. The researcher is responsible for finding a way to minimise such harm.

The second is ensuring that a participant has the choice of whether to participate in the study or not. In other words, it is important to ensure that participants are not subjected to any undue pressure to take apart in the study. The third is ensuring that participants' privacy is protected; the fourth that ensuring that participants will benefit from taking part in the study, as their involvement will take time and effort, and the fifth is that all participants should be treated equally.

Although running an educational RCT will not raise the same type of ethical issues as medical RCTs, there may be either normal or important issues to be resolved; however, educational RCTs seldom raise serious ethical issues (Hammersley & Traianou, 2012).

2.7.2 A theory in practice: RCTs alongside a programme implementation

RCTs in educational studies are usually employed to assess interventions instigated by researchers; therefore, the results are dependent on how the learning interventions are applied. Two issues need to be considered when applying RCTs. First, the social and psychological factors driving the research results are not always understood. Many factors besides the intervention can affect results positively or negatively. In order to understand the effects of these factors, the use of qualitative research methods as a part of the RCT is required (Connolly, 2009).

Second, long-term results cannot be produced by RCTs. It is difficult for a researcher to undertake follow-up research to assess the long-term effects on students of a learning intervention. The results from RCTs are only relevant in the context of the study: a change in the study context can change the study result.

2.7.3 Issues surrounding the implementation of an RCT

A number of issues should be considered when performing RCTs. These issues can affect both the quality of research and the results. In order to implement an RCT it is necessary for the study to be well-prepared. Connolly (2008) discussed this need, and that different methods should be combined in the study in order to achieve a successful trial. The researcher should carefully prepare each stage of the study, identify the study problem and combine different research methods. These should include qualitative methods in order to extract in-depth information with regard to the study problem, and quantitative methods through which to understand the study phenomena and identify the outcomes necessary to explain the effect of the intervention. By carefully following the previously described preparation steps, the researcher can identify the appropriate intervention (Connolly, 2008). Another significant issue is the need to find new and better ways of engaging with teachers (Coe, Fitz-Gibbon, & Tymms, 2000). According to Connolly (2008) the aim of researching into the effectiveness of interventions is mainly to correlate the findings of known interventions. In this case, teachers feel that their roles are limited mainly to designing the RCT, while it is outsiders (researchers) who come in and conduct it in their schools. However, this should not be the case, as large-scale RCTs require the application of small-scale experiments in order to pilot the intervention. This early design stage needs teachers' cooperation with researchers.

According to the Coalition for Evidence-Based Policy (2007), conducting an RCT in educational studies is rare, as it is costly and organisationally too demanding. There are many features of an RCT research study that need funding if they are to be carried out correctly. Organising and preparing the trial, printing papers, training the teachers and students required for the intervention, applying the intervention and collecting the data - all these are aspects are expensive. Organising and preparing an intervention requires extensive paperwork and communication with the relevant authority in order to obtain approval for the research. Travelling might be necessary to follow up the paperwork required. Contact with participating teachers and students can require the organisation of extensive meetings, phone calls and travelling to their schools to organise and prepare the research. When the randomisation is complete, training events for the teachers have to be organised, which might need to be out of school time, in costly private halls. Running tests and surveys requires the extensive printing of research tools, which can be expensive, particularly if the RCT is to be a large-scale study. Applying the intervention in the school can be costly, particularly if the participants require to be paid or incentive payments are made. If the research is done in a different city or country from the one in which the researcher is living, then travel and accommodation costs will be necessary. All these are issues that a researcher might face when conducting an RCT, and which might well deter impecunious, time-limited PhD students in particular from using this research method.

2.7.4 Benefits of conducting RCT research studies in education

There are several benefits in applying RCTs in educational research, one of which is that they can yield highly reliable evidence that can be trusted and accepted by policy makers. It is difficult to produce statistically significant results in large-scale studies, which is one reason researchers avoid them in favour of smaller-scale studies. According to Hutchison and Styles (2010), untested educational interventions are repeatedly accepted by policy makers who recognise too late that they should first have been tested and evidence of their effectiveness produced prior to their adoption.

Unfortunately, the evaluation of new interventions usually takes place after they are widely in use. Hutchison and Styles (2010) suggest that such situations should not arise if an RCT is undertaken and recommend it as the preferred method of educational research.

3 CHAPTER THREE: THE INTERVENTIONS

This research examines the use of peer tutoring and manipulatives, both separately and together. In order to do so, a Randomised Control Trial (RCT) was carried out. The aim of this RCT was to research, pilot, test and develop mathematical pedagogies to improve the learning of mathematics in Saudi Arabia. One control group and three experimental groups were involved in this RCT to investigate whether the use of peer tutoring and manipulatives, separately or together, can affect the learning of mathematics in Saudi schools. This chapter will explain the interventions involved in this study.

This chapter is structured as follows. Section 3.1 will examine the use of peer tutoring, both separately and together, in learning mathematics. Section 3.2 presents the learning processes in the intervention groups. These groups are the manipulatives group, the peer tutoring group, the peer tutoring and manipulatives together group and the control group. This is followed by Section 3.3, which explains how the teachers of each group were trained to apply the interventions. Section 3.4 describes the implementation of peer tutoring and manipulatives, both separately and together, in the experimental groups and the implementation of traditional learning in the control group.

3.1 The use of peer tutoring and manipulatives, both separately and together, in learning mathematics

The literature in Chapters One and Two suggested that an effective learning method should encourage and improve the learning meditation by enhancing students' communication and conversation associated with the subjects being learned. The more the learning meditation is enhanced, the more positive will be the effect on students' learning.

The use of manipulatives cannot guarantee success in the absence of an effective learning methodology that improves the value of the interaction and communication between students which increases the value of their learning mediation. The use of manipulatives was also reported to increase students’ communications, which in turn enhanced their learning of mathematics (NCTM, 2000; Shaw, 2002). The use of manipulatives appears to increase this value by encouraging the learning discussion to focus more on the learning subject; however, they should preferably be used to share learning in an active learning situation.

Peer tutoring, one of the cooperative learning strategies developed in the light of Vygotsky’s description of learning as a social process, has a long and successful history as an effective method of learning, with communications and conversations related to the subjects being learned more likely to improve when peer tutoring is used. Furthermore, the use of peer tutoring positively develops students’ communication and social skills, thus improving the value of the learning mediation.

Students should act sometimes as tutor and sometimes as tutee, thereby, and very importantly, training them to understand the process of the two roles. Well-structured activities are important in any successful peer tutoring; therefore, teachers should plan their lessons and be prepared with the necessary materials for the lesson. Given the importance of involving materials such as manipulatives in increasing the advantages of peer tutoring in mathematics, it is suggested that teachers should provide these manipulatives when they use peer tutoring.

Thus, research studies have clearly shown a relationship between the increase in communication between the students and the improvement in their learning of mathematics using peer tutoring. Therefore, it is suggested that using manipulatives with a social learning strategy maximises the benefits of the use of each. As mentioned in the literature, it cannot be guaranteed that the use of manipulatives will benefit students, unless they are used in an appropriate way.

In conclusion, it is suggested that manipulatives should be used in a social learning strategy and that peer tutoring in learning mathematics should involve the use of manipulatives. While using both manipulatives and peer tutoring separately has been reported to enhance the students' communications, and therefore their learning, the literature on the use of a combination of peer tutoring with manipulatives in learning mathematics is limited. Furthermore, the literature does not explain which is of greater value - the use of peer tutoring or the use of manipulatives; or whether combining them affects students' learning of mathematics positively or negatively.

It is worth examining the effect of their combined use in learning mathematics, as the use of manipulatives and peer tutoring individually affects the students' communication and social skills, and enhances the learning mediation by directing the focus of the students' interaction on to the learning subject, as together they may help both improve the value of the communications and conversations of the students and guide the conversations towards topics related to the subject being learned. It is also possible that peer tutoring and manipulatives may reveal reciprocal benefits when used together. As far as the researcher is aware, this is the first study to examine both the effects and the results of using peer tutoring and manipulatives, both separately and together.

Saudi mathematics teachers are in need of an effective teaching method to help them follow the educational strategies used in more developed countries. This research examines peer tutoring and manipulatives, used separately and together, as effective teaching methods in the Saudi context, to assess whether they could profitably be offered to the education community in Saudi Arabia.

In order to do so, three experimental groups and one control group were used in this RCT. The first experimental group used manipulatives alone as the learning method, the second experimental group used peer tutoring as their learning method, and the third experimental group combined the use of peer tutoring and manipulatives as their learning method. There was no treatment for the control group and they used the learning method they usually used. More detailed information can be found in the methodology sections in Chapters 4 and 5.

3.2 The learning processes in the interventions groups

Two units of the fourth year mathematics curriculum were chosen for the experiment, each of which needed from five to six weeks of teaching. The first unit was about fractions and the second unit was about decimals. These units were clearly related to each other.

There were two reasons for determining the focus of the curriculum units used in the project:

- two units would require twelve consecutive weeks of teaching, which was a reasonable 'dose' and length of 'treatment' for the experiment;
- the complementary relationship between the units made them a good choice for the experiment and the timing of the study meant that these units could be covered during the time frame of the intervention in terms of teaching and chronological position in the school year.

In the control group and manipulatives group, the student's partner was the student sitting next to him in the mathematics class. The researcher asked the teachers in these groups to ensure that each student had the same partner throughout the intervention period.

3.2.1 The manipulatives group

A 12-week programme guideline was developed to guide the teachers in the manipulatives group through their teaching, and the teachers were asked to use the programme at least once a week for 30 minutes. Two classes (one each from a government and an ARAMCO school) were taught using manipulatives in the pilot study and six classes (three each from a government and an ARAMCO school).

The guideline included the following suggested process:

First, the teacher needs to explain to the students the value of using mathematical manipulatives in helping them learn mathematics. Although this explanation is important for the first time of using manipulatives, it is important to refresh the idea to remind the students about it. This process can be done by giving the students an opportunity to explore the manipulatives, start a discussion around what they already noticed and then introduce the subject of the lesson. Then, teachers should explain to the students the similarities and differences between using manipulatives in the maths class and playing with toys or games. They should explain to their students that with manipulatives they are required to use them to find out a solution to a maths problem and their activities and talk with manipulatives should be concerned with this problem, however, they are free to be creative and suggest new ideas.

Teachers should be aware of students' arguing with each other and they should be aware of how they can interact with such issues to get the class back on track. They need to give the students time for free exploration of the manipulatives when introducing new material. This process will engage the students with the manipulatives and give them a chance to be free to use these manipulatives in their learning as they should use the manipulatives themselves to gain the most advantages from their use. It is also important to satisfy the students' curiosity so they do not become distracted from the assigned tasks. After the free exploration, the teachers should find out what students have discovered and write their answers on the board to share the ideas around the class. After the students become familiar with the lesson's concept, it the time to test their understanding by giving them the class task (even the questions from the maths textbook or from the worksheets provided by the researchers as required) to work with it individually and giving them a chance to use the manipulatives and share them around to help them to find the answers.

Manipulatives are usually provided to Saudi schools by the Ministry of Education. However, as there were some schools which did not have them, the researcher provided them where necessary. Two kinds of manipulatives were used in this study. The first was the fraction bars which were used to teach the fraction unit and the second was the base ten blocks which were used in the decimal unit. Fraction bars are among the manipulatives that teachers can use to teach the concept of fractions and mathematical operations with them. It has been reported that the use of fractions bars can enhance students' understanding of both the concept of fractions and operations using them.

Base ten blocks are another mathematical manipulative that can be used to teach and learn a number of mathematical concepts. One of the concepts that base ten blocks can be used for is that of decimals. The individual place values of base ten blocks when they are used to teach and learn decimals are as follows: flats (representing number 1), longs (representing tenths), and units (representing hundredths).

The researcher did his best to ensure that there were enough manipulatives in each class for students to use them individually. However, this proved impossible and there were occasions where the students had to share these manipulatives. The researcher ensured that the manipulatives were passed around the class and the students remained in their places.

3.2.2 The peer tutoring group

A 12-week programme pack was developed to guide the teachers in the peer tutoring group through their teaching, and the teachers were asked to use the programme at least once a week for 30 minutes. Two classes (one each from a government and an ARAMCO school) were taught using peer tutoring in the pilot study and six classes (three each from a government and an ARAMCO school). The teachers who taught these classes were provided with a guideline containing the processes they should follow when using peer tutoring. The pack provided contained full details of the pedagogies and experiments, the tests and questionnaires.

The author of this present research was part of Professor Allen Thurston's group at the University of Stirling in a joint project between the University of Stirling and the University of Dundee on the use of peer tutoring in primary school mathematics. This project was funded by the United Kingdom Economic and Social Research Council and was carried out in schools in Stirlingshire and Falkirk. The peer tutoring materials used in this project were translated from English into Arabic by this present researcher, and adapted from the manual used by Thurston and Topping (2009).

The same-age peer tutoring mathematics programme is a method of learning in maths in which discussion between two students (tutor and tutee) is used to solve maths questions. In this research, it was decided to pair the students of similar ability in the peer tutoring group and have them alternate tutoring roles, which is sometimes referred to as reciprocal peer tutoring. Same ability matching would allow the researcher to suggest an effective method of learning to the class that could help to minimise the teaching changes. This would thus make them more acceptable to the teachers who had never been involved in research and had been never asked to change their teaching methods. It is important to minimise these changes to ensure the teachers' willingness to make the changes in their teaching methods. The reciprocal process in this method improved the ability of both of the pairs to take advantages of the learning process, which increased the students' engagement in the learning process and helped to make them feel they were playing an important role in the learning process. Each student should have the same partner for the two units in all periods of the intervention.

The role of the tutor is to provide support and mediate the learning processes for the tutee. In order to do this the tutor will try to ensure that the tutee attempts to answer maths questions using a structured approach. It is the job of the tutor to keep the tutee working within this structured framework. It is the job of the tutee to do the actual working out to arrive at an answer to a maths question.

The following is a description of the peer tutoring technique and thus is taken directly from the Stirling University website. Peer tutoring focuses on pairs of pupils working together and solving maths questions in three main steps:

- Understanding the question
- Finding an answer to the question
- Finishing the question by asking themselves what have they done and how it links to things they have done in the past.

To facilitate this discussion, the tutee uses the following strategies:

Understanding the question:

- Read
- Identify
- Listen

Finding an answer to the question:

- Question
- Praise
- Think out loud

The tutor should finish the question by talking about what have they done and how it links to things they have done in the past:

- Check the process and the answer
- Sum-it-up
- Link-it-up

3.2.3 The peer tutoring and manipulatives group

A 12-week joint manipulatives guideline and peer tutoring programme pack was provided to guide the teachers through their teaching in the peer tutoring and manipulatives together group, and the teachers were asked to use the programme at least once a week for 30 minutes. Two classes (one each from a government and an ARAMCO school) were taught using manipulatives in the pilot study and six classes (three each from a government and an ARAMCO school). The researcher explained to the teachers who taught these classes how they should apply peer tutoring and manipulatives together in the class. It was explained that the students should support their peer by applying peer tutoring using manipulatives and sharing the manipulatives around the class.

3.2.4 The control group

The control group was taught normally and had 'treatment as usual'. The usual teaching method in Saudi Arabia is that the teachers control the class and all students are silent when the teachers explain everything to them.

3.3 Training teachers

All teachers involved in the interventions attended the training programme. Two professional development sessions were held with the teachers in each of the experimental conditions. During the first meeting, details of the role of the teachers in each of the four experimental conditions, namely peer tutoring, peer tutoring with manipulatives, manipulatives alone and 'treatment as usual' (the control group), were explained, as were the ethics of the study and the teachers' rights as participants in this study. In addition, the researcher provided training sessions on peer tutoring and manipulatives including how to implement this in the classroom. Teachers were given advice on implementing their assigned teaching approaches and provided with information sheets for students. They were also asked to obtain parental permission for the project using a prepared sheet for consent. The parents' agreement sheet included the researcher's contact information for use in the event of any enquiries.

3.3.1 The first meeting programme

The researcher welcomed all teachers involved in the study and thanked them for participating. After this, the researcher gave a brief introduction about the aim of the research, what the study was trying to do, the benefits that could be gained by the study and the potential value of the study to that schools and teachers in Saudi Arabia. In addition, the research process, methodology and tools were explained to the teachers. Their roles and their duties were also explained. The researcher explained to the teachers the two units of the curriculum and why they had been chosen.

The researcher then gave the teachers an idea about the different conditions and asked about the information that teachers already had about them. Some teachers shared their knowledge of the use of manipulatives and what they were, and some of them said that they had heard of the peer tutoring, although they admitted that they had not tried to apply them in their teaching because they had not had clear guidance on applying them in the class and they had not found any training courses to learn how they can be applied. Then, the researcher started giving the teachers more details of the different groups and how each group would use the suggested learning method and apply it to their classes.

The researcher started with the manipulatives group by giving a brief introduction to the manipulatives, such as what they were, what manipulatives would be used in the interventions why they had been chosen, and how the teachers could use them.

Then the researcher moved to the peer tutoring group by explaining what the different kinds of peer tutoring were, what same-age matched ability peer tutoring was, why it had been chosen for this study and how teachers could apply it in the class.

Then the teacher moved to the peer tutoring and manipulatives together group and explained why he tried to integrate the use of peer tutoring and manipulative. Then, the way to use both of them in the class was explained to the teachers.

At the end of the meeting, the interventions pack was provided to the teachers.

The pack contained the following:

1. Introduction to the research
2. Theoretical background to the different interventions
3. Introduction to the different interventions and their teaching processes
4. The research tools
5. Three of worksheets suggested by the teachers for use in the interventions

The researcher asked the teachers to read the pack carefully, as it was to be discussed in the second meeting.

3.3.2 The second meeting programme

The researcher set up a group discussion session on what the teachers had learned from the first meeting and what they learned from the material provided.

Throughout the first period of the session, the researcher tried to address the issues raised by the teachers as they had many technical issues and concerns which needed to be clarified.

In the second period, the researcher explained the testing regime to the teachers in more detail and allowed them to explore their initial ideas. An open discussion was begun with the teachers to discuss the difficulties they might face during the testing. The researcher gave them a chance to suggest solutions and give advice to each other. Then the researcher covered these potential issues and summarised them with the suggested solutions.

In the third period of the second meeting, the researcher explained to the teachers how they should train their students to become involved in the different interventions. Further contact was maintained with the teachers through weekly meetings with the researcher during the 12-week implementation. During these meetings, the teachers discussed any issues they were facing. Subsequently, other teachers, in particular those who had faced similar issues, were able to talk about their experiences and suggest solutions to the issues. This allowed trouble-shooting and professional development advice to be given on demand.

3.3.3 Supporting teachers and troubleshooting through observations and peer supports

The researcher made at least two observations visits to each class. The main reason for the observations was to check the fidelity of implementation of the learning process in the classroom and answering teachers' questions about the application.

The researcher accessed the class and sat in the rear trying not to disturb the class and to observe the learning process. The researcher made notes if necessary of things that need to be checked with the teachers. After the class the researcher had a one-to-one meeting with the teacher and discussed the points which had arisen in the observation visit.

One of these visits took place in the first two weeks of the interventions and the second, in the fifth and sixth weeks. More visits applied to teachers who needed more support to apply the intervention more effectively. The researcher suggested a class visit to one of the teachers who applied the intervention effectively.

The researcher provided the teachers with his contact information, mobile number and email address in order to be available to support the teachers and answer their questions at any time. Many phone calls were received from teachers, some of them in the evening and some of them during teaching time, to ask about certain issues they faced.

3.4 Implementation of peer tutoring and manipulatives, both separately and together, in the experimental groups and implementation of traditional learning in the control group

The teachers were asked to use the programme at least once a week for 30 minutes. The experimental groups' classes were allocated study types as follows:

- Two classes (one each from a government and an ARAMCO school) in the pilot study and six classes (three each from government and ARAMCO schools) in the main study were taught using the peer tutoring strategy;
- Two classes (one each from a government and an ARAMCO school) in the pilot study and six classes (three each from government and an ARAMCO schools) in the main study were taught using manipulatives, the teachers who taught these classes having been provided with a pack containing the processes they should follow when using manipulatives;
- Two classes (one each from a government and an ARAMCO school) in the pilot study and six classes (three each from government and ARAMCO schools) in the main study used peer tutoring and manipulatives at the same time, using the pack developed to guide the teachers, and;

- Two classes (one each from a government and an ARAMCO school) in the pilot study and six classes (three each from government and ARAMCO schools) in the main study were assigned to the control group. They were not provided with any new materials. The control group was taught normally and had ‘treatment as usual’.

3.4.1 The pre-testing and training students

In this week, the teachers had two tasks. The first was to pre-test the students on the two research instruments (the attainment test and the attitude towards mathematics questionnaire) in the pilot study and the four research instruments (the Attainment Test, the Attitude Towards Mathematics questionnaire, the Attitude Towards Learning Partner questionnaire and the Sociometric questionnaire). An arrangement with the teachers involved in all groups and their schools’ head teachers was made to carry out the pre-test in all classes at the same time. Each instrument was applied on a different day in the third period of the study day. The aim of applying each research tool on a different day was to not give the students too many things in one day. The choice of the third period to do the pre-testing was made for a number of reasons, such as not testing them at the beginning of the study day and not at the end so they might be more able to do the different tests. In addition, the researcher avoided the first period as some students may have been late and the last period as the students may have been tired at the end of the study day or some of them may have had to leave school early.

The second task was to train the students in the experimental groups how to act in their role of learning through the interventions. The teachers were given a guide as to how to train their student in the training sessions. The researcher was in contact with the teachers throughout the week by phone to track the testing and ensure the application of the pre-testing and students' training. The researcher received a number of calls during this week from teachers asking about some issues that they were facing. At the end of this week the researcher contacted the teachers to gather the information on both pre-testing and students training.

3.4.2 Week one

In this week, the teachers started to apply the interventions in their classes as they had been asked. Selections of questions from the maths textbook were chosen for use in the interventions groups. In this week the researcher visited some of the teachers to ensure the applications of the learning methods.

3.4.3 Week two

The teachers were asked to use the first worksheet provided by the researcher to apply the interventions. The first worksheet contained selections of questions that the researcher had built according to the maths subjects of this week. In this week, the researcher continued to make the first observational visits to the teachers who had not yet been visited to ensure the applications of the learning methods.

3.4.4 Week three

Selections of questions from the maths textbook were chosen for use in the interventions groups. In this week the researcher made more observational visits to the teachers had been visited previously and had the impression that more support was required to apply the learning process more effectively.

3.4.5 Week four

Selections of questions from the maths textbook were chosen for use in the interventions groups. In this week, the researcher continued to do more observational visitations to the teachers who had been visited previously, and had the impression that more support was required to apply the learning process more effectively.

3.4.6 Week five

The teachers were asked to use the second worksheet provided by the researcher to apply the interventions. The second worksheet contained selections of questions that the researcher built according to the maths subjects of this week. In this week, the researcher started making the second observational visits to the teachers from the peer tutoring only group and the teachers from the peer tutoring and manipulatives together group as the researcher felt that they needed more support.

3.4.7 Week six

Some questions from the maths textbook were selected for use in the interventions groups. The researcher carried out the second observational visits to the teachers of the manipulatives only group and the control group.

3.4.8 Week seven

As in Week Six, some questions from the maths textbook were chosen for use in the interventions groups. In this week, the teachers from the interventions groups who needed more support were visited by the researcher.

3.4.9 Week eight

As in the two previous weeks, some questions from the maths textbook were selected for use in the interventions groups. More observational visits were carried out by the researcher to the teachers from the interventions groups who required more support.

3.4.10 Week nine

The teachers were asked to use the third worksheet provided by the researcher to apply the interventions. The third worksheet contained selections of questions that the researcher built according to the maths subjects of this week. In this week the researcher continued making observational visits to the teachers who needed extra support.

3.4.11 Week ten

Selections of questions from the maths textbook were chosen for use in the interventions groups. In this week the researcher continued the more observational visits to the teachers from the interventions groups who needed more support.

3.4.12 Post-testing

This was the week of students' post-testing on the two research instruments (the Attainment Test and the Attitude towards Mathematics questionnaire) in the pilot study and the four research instruments (the Attainment Test, the Attitude Towards Mathematics questionnaire, the Attitude Towards Learning Partner questionnaire and the Sociometric questionnaire) in the main study. An arrangement with the teachers involved in all groups and their schools head teachers had been made to carry out the post-tests in all classes at the same time. Each instrument was applied on a different day in the third period of the study day, as had been done in the pre-tests.

In the main study, this also was the week of interviewing the teachers and the students from the interventions groups (more details about the interviews can be seen in the methodology chapter).

The researcher was in contact with the teachers throughout the week by phone to track the testing and ensure the application of the post-testing.

4 CHAPTER FOUR: THE PILOT STUDY

This chapter concerns the pilot study. There are many reasons for the researcher's conducting a pilot study. First of all, the researcher wished to test the feasibility of school environments and teachers in Saudi Arabia being part of a Randomised Controlled Trial (RCT). The literature on RCTs in education in Saudi Arabia is scarce and therefore the researcher carried out a pilot study to have an initial idea of the potential of doing RCTs in Saudi Arabia. Another reason for doing this pilot study was to test whether the protocol designed for the study would be useful and practical for the main study. Through the pilot study, the researcher also tried to develop and test the adequacy of the research instruments and the testing regime. In addition, the researcher tried to find out if the sampling framework and technique were effective and possible. He also attempted to identify the issues and problems that might appear during the application of the interventions and the research instruments. Further, the researcher tried to estimate variability in outcomes to help determining sample size. Moreover, an attempt was made to collect initial data that could help to find out if changes could be detected from the interventions and if the intervention period and the units of the curricula were practical and useful. The researcher tried to decide what resources (finance, staff) were needed for the planned study, as well as testing the proposed data analysis techniques to uncover potential problems and find out the analyses framework. The pilot study is one of the best ways to train the researcher in as many elements of the research process as possible and to determine if the main study is feasible and worth funding. From the pilot study, the researcher tried to discover whether other research methodologies, research instruments, phenomena relating to the teaching and learning needed to be added to the main study.

The reasons above and the outcomes of the pilot study which will be discussed later in this chapter, show the importance of conducting the pilot study in this RCT.

This chapter will be structured as follows. The research methodology of the pilot study will be presented in section 4.1, and the results of the pilot study in section 4.2. Section 4.3 will explain the value of the pilot study and what has been learned from it.

4.1 Research methodology of the pilot study

This is the research methodology section of the pilot study. It will begin by giving a general background to the research methodology, the sampling and a justification for using RCT as the research method used in this study.

Further, the design of the pilot study, the study population the pilot study sampling, the pilot study research instruments, the study variables in section, the data collection schedule, and the data analysis will be discussed in this section.

4.1.1 General background of research methodology

This section will describe educational research paradigms, or families, at a general level. Definitions of each paradigm will be considered and discussed. There are two main paradigms that can be considered in educational research: the positivist, objective and scientific quantitative paradigm and the interpretative, subjective, naturalistic qualitative paradigm (Denzin & Lincoln, 2000).

The first, the positivist, objective and scientific quantitative paradigm, can be defined as an investigation of a specific problem. It is usually used to test a theory, calculated with numbers and analysed statistically (Johnson & Christensen, 2007). That means that this paradigm is used to establish whether a theory works or not and to measure, by numbers and figures, the research aim(s) that uses this paradigm. This paradigm usually uses statistical techniques to help researchers reach their results. Variables, which can be defined as abstracts that take on different values, are the basic building blocks of quantitative research. Variables are the opposite of constants, which can be defined as abstracts that cannot vary (Johnson & Christensen, 2007).

There are three types of variable that might be used in quantitative research. The first type is the independent variable, which is presumed to cause changes in another variable, the second type is the dependent variable, which changes because of another variable, and the third type is the intervening variable, which is a variable occurring between two other variables (Johnson & Christensen, 2007).

There are three ways of approaching quantitative research. These are experimental research, quasi-experimental research and correlational research. Experimental research aims to understand the relationships between cause and effect. In this type of research an active manipulation of an independent variable might be used; additionally, a random assignment might be used in the strongest experimental research designs (Johnson & Christensen, 2007).

In quasi-experimental research, neither the active manipulation of an independent variable nor a random assignment is used. This means that if a relationship is found, there may be a number of possible explanations for such a relationship. In other words, researchers using this method cannot reach a definitive conclusion with regards to causal relationship, but it may be considered with other corroborating evidence.

In correlational research, causation cannot be inferred. This type also uses the recording of variables and observation rather than systematically manipulating variables. In the positivist paradigm, there are many possible data collection methods, such as questionnaires. Data are then statistically analysed in order to answer the research questions (Johnson & Christensen, 2007).

The second main paradigm is the interpretative, subjective, naturalistic qualitative paradigm (Denzin & Lincoln, 2000). This paradigm seeks a deeper understanding of the given research problem or of a phenomenon from the perspectives of the study sample. Different abstracts can be considered in qualitative research, such as the values, opinions, behaviours and social contexts of the research sample. This means that the qualitative paradigm is different from the quantitative one as it searches for a deeper explanation of the research questions rather than searching for the relationship between the causes and the effects (Johnson & Christensen, 2007).

There are five main types of qualitative research: phenomenology, ethnography, case study research, narrative research and evaluation research (Creswell, 2013). Although all these approaches are similar, as they are all qualitative approaches, each has its own characteristics that should be taken into account in order to fulfil the aims of the approach.

According to Connolly (2009), there are two types of empirical research into the effectiveness of education. In one, the researcher tries to decide whether the intervention of a particular educational programme is effective or not and explain the effects that are found. In the other, the researcher tries to decide whether the intervention of a particular educational programme is effective or not and focus on clarifying whether that intervention succeeded in achieving the expected effects.

The Randomised Controlled Trial (RCT) appears to be the most persuasive type of research that can give clear evidence around such issues. The RCT includes the use of pre- and post-tests on main outcome measures in both the control group(s) and the experimental group(s) to find out whether there has been a change in the outcomes after the intervention. In addition, any differences in main outcome measures that have been found should be compared between the control group(s) and the experimental group(s) in order to establish whether the intervention is the likely cause of the increase or not (Connolly, 2009).

Connolly (2009) further states that in the research studies into effectiveness, it is difficult to decide what the causes of these effects might be. The use of different research methods, both quantitative and qualitative, is required in order to design good studies that can produce robust evidence for the causes.

As Connolly (2009) asserts, the use of both qualitative and quantitative methods is required in order to evaluate thoroughly the effectiveness of an educational intervention. Furthermore, involving both methods helps the researcher to understand the nature of the problem under review, enabling the specific outcomes which help to develop the appropriate intervention to be identified.

However, another aspect of the RCT should be taken into account. Oakley et al. (2006) point out that the majority of RCTs focus on outcomes, but neglect the processes involved in implementing an intervention. They further argue that the inclusion of a process evaluation would enhance the science of many RCTs. They suggest the use of various methods of evaluation, such as surveys, individual interviews and focus groups (Oakley, 2006).

4.1.1.1 Sampling

In the quantitative paradigm, there are two main techniques of sampling. The first is the random technique, where the researcher randomly chooses the research samples. In this technique, every member of the research population has an equal opportunity of being involved in the research process.

The second technique is non-random sampling. There are four types of non-random sampling. The first type is convenience sampling, a non-probability sampling technique whereby subjects are selected for the convenience of their accessibility and proximity to the researcher. As the name suggests, this can be used when researchers simply want to involve the most convenient population sample to hand. The second type is quota sampling, a method of gathering representative data from a quota of subjects drawn from a specific sub-group of the population. The third type is purposive sampling, which can be used when researchers need to find samples with similar characteristics, such as age group or gender. The fourth type is snowball sampling. Researchers using this type of non-random sampling try to find further participants by asking the first participants to identify others. However, in the qualitative paradigm researchers mainly use the purposive technique in their sampling. They can use this technique in a number of ways, such as by selecting a small and homogeneous case, selecting typical or average cases or selecting cases that are known to be very important (Johnson & Christensen, 2007).

4.1.1.2 Justification for using RCT in this research study

The RCT appears to be the most appropriate type of research to give clear evidence on issues relating to research studies on effectiveness (Connolly, 2009). Although the use of RCTs is unusual in educational studies (Topping et al., 2011), the results of studies of this kind are considered to yield premium quality evidence. Tymms et al. (2011) suggest that the use of RCTs can be helpful in creating educational policy at the highest level, and they are highly recommended in the making or development of such policy. A number of benefits can be gained by applying RCTs in educational research, one of which is that they can produce authoritative evidence that can be highly trusted by policy makers since, while it is easy to produce apparently significant results from a small sample, when similar results are obtained from a much larger sample they carry correspondingly much greater weight. According to Hutchison and Styles (2010), the situation repeatedly arises with educational interventions in which an untested intervention is accepted by policy makers who only then recognise that this new intervention should be tested and sound evidence of its effectiveness should be produced. Unfortunately, the evaluation of a new intervention usually takes place after it is widely in use. Hutchison and Styles (2010) suggested that where an RCT is applied, the above situation should not arise. In order to discover whether an intervention works or not, an RCT should be considered as the first method to be used (Hutchison & Styles, 2010). According to Connolly (2009), in research studies seeking effectiveness, it is difficult to decide on the causes of these effects. The use of different research methods such as qualitative and quantitative methods is required in order to design sound studies that can produce evidence for those causes. Involving qualitative methods together with quantitative methods is required in order to make an appropriate evaluation of the effectiveness of educational intervention. In addition, involving both methods is helpful for understanding the nature of the study problem and this allows specific outcomes which help to identify the intervention most appropriate for development.

4.1.2 Design of the pilot study

In the study, a randomised controlled factor design was used to measure the effects of using manipulatives, peer tutoring (PT), and peer tutoring plus manipulatives on mathematical attainment, as compared to a control group that used the normal method of teaching, that is, 'treatment as usual'. In order to examine and evaluate outcomes, a pre- and post-test design was used.

Manipulatives	**RO_1**	**X_1**	**O_2**
Manipulatives+PT	**RO_3**	**X_2**	**O_4**
PT	**RO_5**	**X_3**	**O_6**
Control	**RO_7**		**O_8**

X= Independent variable

O= Dependent variable

There were three experimental groups. Teachers assigned to the first experimental group used manipulatives to support their teaching strategy. Those assigned to the second experimental group used peer tutoring only, and those assigned to the third experimental group used both manipulatives and peer tutoring. The control group used the normal method of teaching, that is, ‘treatment as usual’.

The pre-test was carried out before the experiment took place and the post-test at the end of the treatment period. Both pre- and post-tests were paper and pencil tests that took 30 minutes to complete and were administered by participating teachers. The intervention was used for 12 weeks, and post-tests were undertaken one week after the intervention in both the experimental and control classes. More information on the application of the interventions and the pre- and post-testing regime can be seen in Chapter Three.

4.1.3 Population

The aim of this study was to evaluate the effect of using peer tutoring and manipulatives, both separately or together in year 4 (i.e., with learners aged 10-11) in elementary schools in AlAhsa, Saudi Arabia. AlAhsa is one of the biggest cities in the Kingdom of Saudi Arabia, and it has a number of such schools. All the mathematics teachers who participated in this study were Saudi male teachers aged from 26 to 35 years old who had qualified in one of the teachers’ colleges majoring in mathematics that are to be found in each major city in Saudi Arabia, and which were run by the Saudi Ministry of Education. These colleges later became part of the Ministry of Higher Education. All participating teachers had from four to 12 years’ experience of teaching mathematics.

Elementary education refers to years one to six (learners aged from six to 13). It is a very critical stage, particularly in Saudi Arabia where the majority of the population is young and the results of using effective learning methods can benefit society in the future. In addition, the teaching methods currently used are widely considered as not being appropriate for learning as the results of mathematics exams show that the students' outcomes are not promising.

Male students in the fourth year were chosen to represent the elementary school students in this study. One of the reasons for selecting this sample was that the Ministry of Education in Saudi Arabia had started a development project to change the school curriculum and at the time of the study only the fourth year students were following the new curriculum. Moreover, the education policy in Saudi Arabia separates male and female students into different schools. The male students' schools are administered by male teams and students are taught by male teachers. The female students' schools are administered by female teams and students are taught by female teachers. As the researcher in this study is male, he was not allowed access to the female schools.

Another reason for selecting year four elementary students was that previous studies (Thurston et al., 2010; Thurston et al., 2012) had shown peer tutoring to be particularly effective with this age range of students. Two units of the fourth year mathematics curriculum were chosen for the experiment, each of which needed from five to six weeks of teaching. The first unit was about fractions and the second unit was about decimals. These units were clearly related to each other.

More information on the reasons for determining the focus of the curriculum units used in the project can be seen in Chapter Three.

There are two main kinds of school in AlAhsa city – the government schools built by the government and those built by ARAMCO (the largest oil company in Saudi Arabia). Both are run by the education authority and follow official Saudi Arabian education policy. ARAMCO schools are single storey, high quality buildings, while government-built schools are two or three storeys high and the quality of building and maintenance is lower than those normally found in ARAMCO schools. The spaces both inside and outside the classrooms, and in the outside yards of ARAMCO schools, are larger than those in governmental schools. There are usually more classrooms and classes per year in ARAMCO-built schools than in government-built schools. Therefore, although the number of government schools is greater than the number of ARAMCO schools, the overall number of classrooms and students is almost the same for both kinds of school. It is essential to find out whether other conditions prevailing in the school would affect the use of peer tutoring, with or without manipulatives, in learning mathematics in AlAhsa city. Since the differences between government- and ARAMCO-built schools may have affected the outcomes in this study, an equal number of schools was recruited from each type.

4.1.4 Sample

The schools that participated in this study were randomly assigned to conditions. The study involved eight classes, one in each of eight schools. In order to recruit schools, a letter explaining the study and its method and design was sent by the education authority in AlAhsa city to all elementary schools encouraging them to volunteer for the project. Classes in the participating schools were then block assigned, by ballot, from lists of government and ARAMCO schools, to ensure equal numbers of each type of school in each treatment cell; the schools were then contacted and informed of their assignment to the experiment.

After the initial agreement had been made by phone, the researcher started to visit the schools one by one, personally meeting with the school administrators and fourth year mathematics teachers to explain the study and the work required. They were all most interested in the study and highly cooperative.

Table 4-1 explains the study sample in detail.

Table 4-1: The details of the pilot study sample (generated by author)

SCHOOL CODE	SCHOOL TYPE	CLASS	TEACHER CODE	GROUP	NUMBER OF STUDENTS	TOTAL GROUP
S01	ARAMCO	A	T01	1	25	39
S02	GOVERNMENT	A	T02	1	14	
S03	ARAMCO	A	T03	2	28	48
S04	GOVERNMENT	A	T04	2	20	
S05	ARAMCO	A	T05	3	30	54
S06	GOVERNMENT	A	T06	3	24	
S07	ARAMCO	A	T07	4	29	51
S08	GOVERNMENT	A	T08	4	22	
Total					192	192

More information about the teachers' and students' training in the application of the different interventions can be found in Chapter Three.

4.1.4.1 Sample size

As the main aim of this study was to pilot the main study materials (tests and questionnaires), the sample was not large.

Eight representative elementary fourth year classes were selected: four from ARAMCO schools and four from government schools. The classes were then assigned to the different conditions.

More information on the implementation of peer tutoring and manipulatives, both separately and together, in the experimental groups and the implementation of traditional learning in the control group can be seen in Chapter Three. Chapter Three also gives more information on the teaching conditions in each group.

4.1.5 Research instruments

4.1.5.1 Attainment test

A criterion-referenced attainment test that focused on the mathematics units used in the study was developed by the researcher. The test was piloted by a number of mathematics teachers and six classes took the test as a pilot group to assess its suitability. The reliability of the test was analysed (Cronbach's alpha 0.33 with a group of 47 Saudi Arabian students aged 11 years). As the main aim of this study was to pilot the research instruments, the final version of the test was developed to ensure there were no ceiling and floor effects. All eight classes involved in this study took the test twice: once before the experiment and once after it. The results of the tests were statistically analysed to discover if there were statistically significant differences between the students' attainment scores before and after the use of peer tutoring and/or manipulatives. The Statistical Package for the Social Sciences (SPSS) programme was used to analyse and generate the results of the tests.

4.1.5.2 Attitude of students towards mathematics

A 21-item questionnaire investigating changes in student attitudes to mathematics during the study was also administered. This questionnaire was translated from English to Arabic and then slightly adapted to suit the context from the modification made by Thurston et al. (2010) of a questionnaire previously designed by Pell and Jarvis (2001). It was originally designed to measure students' attitude towards science, and had proven reliability and validity (Cronbach's alpha 0.74 with a group of 116 UK students aged 11 years). The reliability of the test had been established in this present research (Cronbach's alpha 0.55 with a group of 39 Saudi Arabian students aged 11), although the SPSS suggested that by deleting item number 21 (We have to do too much number work in maths), the reliability would be further increased (Cronbach's alpha 0.80 with a group of 39 Saudi Arabian students aged 11). In this study, the researcher therefore decided to delete item number 21. Hence, the final questionnaire comprised 20 items, and had been piloted by several colleagues who worked at a number of education departments in Saudi universities as well as by several teachers. The final questionnaire can be seen in the Appendices (see Appendices 2 & 3). The questionnaires were statistically analysed to identify significant differences between students' attitudes to mathematics before and after the use of peer tutoring and manipulatives, both separately and together. The SPSS programme was also used to analyse and produce the results of the questionnaires.

4.1.5.3 Observational visits

At least two observational visits to each class were made by the researcher. The main reason for the observations was to check the fidelity of implementation of the learning process in the classroom and to answer teachers' questions about the application. More information on the aim, methods of collecting data and the value of doing these visits can be seen in Chapter Three.

In addition to the main aim of the observational visits, the researcher made notes of changes he noticed in the students' learning. Although the researcher did not use a specific research tool, he gathered as much as information he could. Making such notes was helpful for the researcher in making decisions on many issues reflected in the main study methodology.

These visits also served to clarify the following issues for the researcher, as well as being part of the teachers' training:

- How well do the teachers follow the plan?
- How well do the teachers adhere to the interventions as intended?
- To what extent do the teachers stay true to the interventions and avoid drifting?
- Do the teachers adhere to the time plan?
- Was the quality of delivering the interventions as expected?
- Do the students engage in the learning as expected?
- Do the students apply the interventions as expected?
- What kind of training do they need to improve their application?

4.1.6 Variables

The independent variables of this study were the methods of peer tutoring, manipulatives, and the use of both peer tutoring and manipulatives together. The dependent variables in this study were scores in the achievement test and scores from the attitude to mathematics questionnaire.

The controlled variables in this study were teachers, time, average age, school type, and classroom conditions.

The uncontrolled variables in this study were teachers' previous achievement, socioeconomic status, anxieties, self-concept, interests and attitudes.

4.1.7 Data collection

Below can be seen a table showing the steps taken in the collection of data.

Table 4-2: The data collection schedule

Week	Start date	Task
1	5-3-2011	Paperwork and choice of schools
2	12-3-2011	Meetings with the teachers Training course Pre-tests and pre-questionnaires for students, and first observation
3	19-3-2011	Worksheet (1)
4	26-3-2011	Worksheet (2)
5	2-4-2011	Worksheet (3)
6	9-4-2011	Vacation
7	16-4-2011	Worksheet (4)
8	23-4-2011	Worksheet (5)
9	30-4-2011	Worksheet (6)
10	7-5-2011	Worksheet (7)
11	14-5-2011	Worksheet (8)
12	21-5-2011	Worksheet (9)
13	28-5-2011	Worksheet (10)
14	4-6-2011	Post-tests and post-questionnaires for students, and final observation

4.1.8 Analyses of the data

All the related data were analysed in order to test the study's hypotheses and assumptions. All the descriptive statistics (mean, standard deviation and difference of means) were computed for each condition. The researcher conducted two-way repeated measures ANOVA on the independent sample to measure the significance of the difference between the means within conditions. The significance of difference between the mean scores within condition on the variable of pre- and post-test scores was tested at 0.05 level. Three-way between-subjects ANOVA, with Bonferroni *post-hoc* as needed, were used to analyse differences in conditions between the gains of the pre- and post-tests in outcomes.

The following formula: (the mean of the post-test – the mean of the pre-test) in each group, was used to arrive at the gain scores. The gain scores were analysed using both the two-way repeated measures ANOVA and the three-way between-subjects ANOVA, with *post-hoc* rather than ANCOVA. Although the latter is generally believed to be a stronger analysis than ANOVA of gain scores, the researcher decided to use ANOVA. This was because of the nature of the data in this RCT, as there were no significant pre-test differences and a Bonferroni correction was used to justify the ANOVA.

4.2 Results of the pilot study

A variety of research methods were used in this RCT study, and therefore the results of this research are presented in four different chapters, each of which discusses the results of one of the main elements. This chapter will discuss the results that emerged from the pilot study, the data from the analysis of the Attainment Test, and the Attitude Towards Mathematics questionnaire and the value of conducting the pilot study.

4.2.1 Effect on attainment

A criterion-referenced attainment test that focused on the mathematics units used in the study was developed by the researcher. More detailed information on the test can be found in the methodology section in this chapter.

4.2.1.1 Reporting the mean and the effect sizes of the Attainment Test

Table 4-3 shows the mean of the pre and post-test data, with Standard Deviation (*SD*) in each condition. Only data for students who completed both pre- and post-test are presented. Attrition was low (seven students) and therefore there were no implications for the data in this regard. Table 4-3 also shows the effect sizes in this research study.

The data indicated that there were significant gains in the mean score in each condition.

The peer tutoring and manipulatives together group had the greatest change as the mean of its pre-test score was 3.78 (*SD* 1.88) and the mean of its post-test score was 10.29 (*SD* 4.75). The mean of change (pre-test – post-test) of the peer tutoring and manipulatives group scores was 6.51 (*SD* 3.29).

Data from the control group showed the least change. There were differences between the mean scores: the mean of the pre-test was 3.23 (*SD* 1.85), the mean of the post-test was 4.98 (*SD* 2.48) and the mean of the change (pre-test – post-test) was 1.74 (*SD* 2.71).

The mean effect size of the intervention was 1.466. At 80% power and p=0.05 this indicated that the sample sizes were large enough to deduct effect at this level. The Daniel Soper sample size calculator indicated that the minimum sample size should be nine per group for a two-tailed t-test (Soper, 2014).

4.2.1.2 The changes in mean score in the pre- and post-tests of the attainment test

Analysis indicated that the pre- and post-tests in each condition were normally distributed and therefore pre- and post-test differences within condition were analysed using a two-way repeated measures ANOVA. This was conducted to assess whether the differences between pre- and post-test scores were significant among the conditions.

The results revealed that the post-test mean scores were significantly higher than the pre-test mean scores within conditions: $F(3,188)= 13.123$, $p< .001$, partial $ή^2 = .173$. The interaction is displayed in Figure 4-1, showing a positive slope for all groups from the pre- to post-tests. Therefore, paired-samples *t*-tests were conducted to assess whether the differences in the pre- and post-test scores were significant in each group.

The results revealed that the post-test mean scores were significantly higher than the pre-test mean scores in each condition; the control group (t (46) = -4.41, p < 0.001), the manipulative group (t (51) = -4.94, p < 0.001), the peer tutoring group (t (56) = -16.26, p < 0.001) and the combined manipulatives and peer tutoring group (t (55) = -7.78, p < 0.001).

4.2.1.3 The differences between the groups' mean scores in the Attainment Test

The results of the two-way repeated measures ANOVA revealed that when the results of the pre-test were subtracted from those of the post-test, there were significant differences between the groups: $F(3,188)= 14.764$, $p< .001$, partial $ή^2 = .191$.

The three-way between-subjects analysis of variance (ANOVA) is a statistical test that is usually used to compare the means between the groups. It helps to decide if any of these means are significantly different from each other. The three-way

ANOVA revealed that there were significant differences between the groups: $F(3,188)= 13.123$, $p< .001$, partial $ή^2 = .173$.

Therefore, a three-way between-subjects ANOVA with Bonferroni *post-hoc* test was conducted on the differences between the students' scores in the students' Attainment Test to compare the differences between conditions.

These differences revealed were statistically significantly higher in the peer tutoring group than the control group ($p = .009$). The combined peer tutoring and manipulatives group's mean scores were statistically significantly higher than those of the control group ($p< .001$). The combined peer tutoring and manipulatives groups' mean scores were statistically significantly higher than those of the manipulatives group ($p< .001$). The combined peer tutoring and manipulatives group's mean scores were statistically significantly higher than those of the peer tutoring only group ($p = .039$).

However, statistically insignificant differences were found between the manipulatives group and the control group ($p = 1$) and between the manipulatives only group and the peer tutoring only group ($p = .198$).

Table 4-3: The mean changes in the pre- to post-test scores in the Attainment Test

Group code	1	2	3	4
Group name	Control	Manipulative	Peer tutoring	Peer tutoring and manipulatives
Number of students	(n=47)	(n=52)	(n=57)	(n=56)
Number of classes	(n=2)	(n=2)	(n=2)	(n=2)
Pre-test	3.23 (1.85)	3.06 (1.64)	2.80 (1.68)	3.78 (1.88)
Post-test	4.98 (2.48)	5.73 (3.61)	7.19 (3.79)	10.29 (4.75)
Pre-post (change)	1.74 (2.71)	2.67 (3.90)	4.39 (3.29)	6.51 (4.83)
Effect size		0.425	2.467	1.506

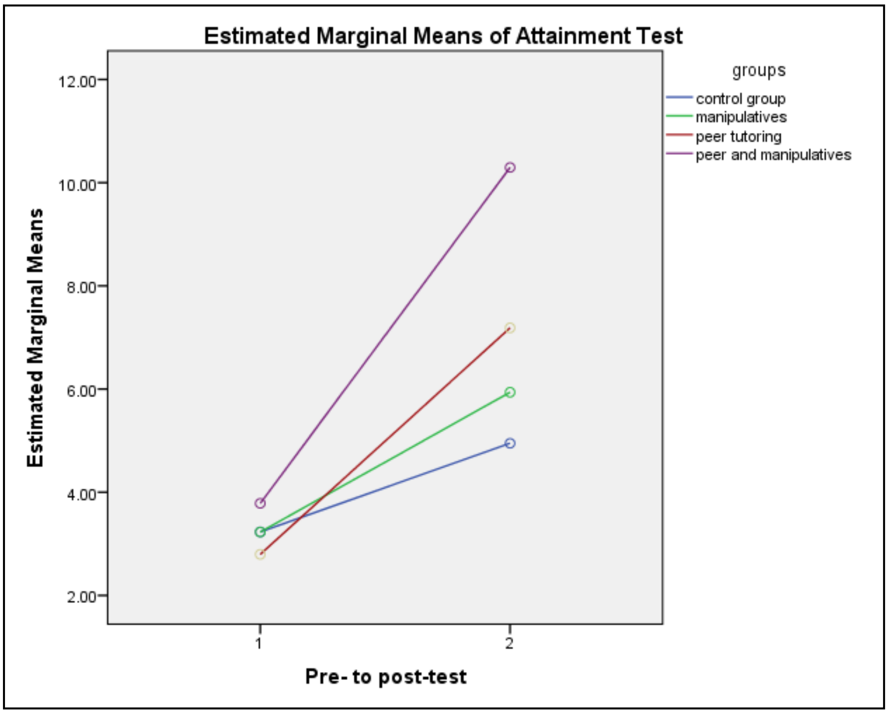

Figure 4-1: The changes in the mean scores from the pre- to post-test in the Attainment Test

4.2.2 Affective outcomes

A 20-item questionnaire investigating changes in student attitudes to mathematics during the study was also administered. More detailed information on this questionnaire can be found in the methodology section in this chapter.

4.2.2.1 Reporting the mean and standard deviation of the Attitude Towards Mathematics questionnaire

Table 4-4 presents the means of the pre- and post-test Attitudes Towards Mathematics questionnaire, with Standard Deviation (*SD*) in each condition. Only data for students who completed both pre- and post-test are presented. Attrition was low (seven students) and therefore there were no implications for the data in this respect.

The peer tutoring and manipulatives group demonstrated the greatest change as the mean pre-test score was 83.14 (*SD* 15.18) and the mean post-test score was 88.18 (*SD* 7.25). The mean of change (pre-test – post-test) of the peer tutoring and manipulatives group score was 5.04 (*SD* 17.82). The peer tutoring group showed negative change, as the mean pre-test was 84.70 (*SD* 13.37), and the mean post-test score was 82.33 (*SD* 15.67), and the mean change (pre-test – post-test) was -2.37 (*SD* 19.83).

4.2.2.2 The changes in mean scores in the pre- and post-tests of the Attitude Towards Mathematics questionnaire

Analysis indicated that the pre- and post-tests in each condition were normally distributed and therefore pre-test and post-test differences within conditions were analysed using a two-way repeated measures ANOVA in order to assess whether the differences between pre- and post-test scores were significant in the conditions.

The results revealed that the differences between the post-test mean scores and the pre-test mean scores were insignificant within conditions: $F(3,188) = 2.579$, $p = .055$, partial $ή^2 = .040$. The interaction is displayed in Figure. 4-2, showing a positive slope for the combined peer tutoring and manipulatives group and a negative slope for the peer tutoring group from the pre- to post-tests. Therefore, the paired-samples *t*-tests were conducted to assess whether the differences between pre- post-test scores were significant in peer tutoring and manipulatives together group and peer tutoring only group. The post-test mean scores were significantly higher than the pre-test mean scores in the combined peer tutoring and manipulatives group (t (50) = - 2.02, p = 0.049), however, the differences between post-test mean scores and the pre-test mean scores were insignificant in the peer tutoring group (t (53) = 0.88, p = 0.384).

4.2.2.3 The differences between the groups' mean scores in the Attitude Towards Mathematics questionnaire

The results of the two-way repeated measures ANOVA revealed that when the pre- and post-tests were combined there were significant differences between the groups: $F(3,188) = 6.427$, $p < .001$, partial $ή^2 = .093$.

Therefore, a three-way between-subjects ANOVA with Bonferroni *post-hoc* test was conducted on the differences between the students' scores in the students' Attitude Towards Mathematics questionnaire to compare the differences between conditions. The three-way ANOVA results revealed that there were significant differences between groups: $F(3,188) = 2.579$, $p = .55$, partial $ή^2 = .040$.

Insignificant differences were found between the manipulatives group and the control group ($p = 1$), between the control group and the peer tutoring group ($p = .798$), between the control group and the combined peer tutoring and manipulatives group ($p = 1$), between the manipulatives only group and the peer tutoring only group ($p = 1$), or between the manipulatives only group and the combined peer tutoring and manipulatives group ($p = .822$).

The differences between the students' scores in the attitudes towards mathematics questionnaire was significantly higher in the combined manipulatives and peer tutoring group than in the peer tutoring group ($p = .039$).

Table 4-4: The changes in the mean scores from the pre- to post-test in the Attitude Towards Mathematics questionnaire

Group code	1	2	3	4
Group name	Control	Manipulative	Peer tutoring	Peer tutoring and manipulatives
Number of classes	(n=2)	(n=2)	(n=2)	(n=2)
Number of students	(n=39)	(n=48)	(n=54)	(n=51)
Pre-test	80.59 (15.04)	83.40 (10.52)	84.70 (13.37)	83.14 (15.18)
Post-test	82.79 (14.32)	83.77 (11.27)	82.33 (15.67)	88.18 (7.25)
Pre-post (change)	2.21 (3.83)	0.38 (2.94)	-2.37 (19.83)	5.04 (17.82)

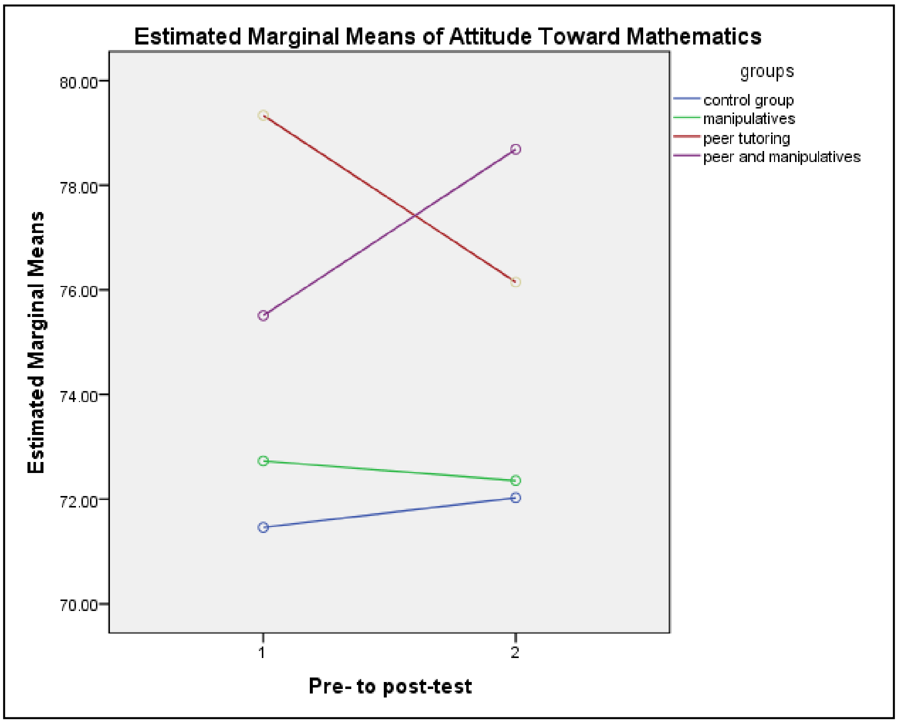

Figure 4-2: The changes in the mean scores from the pre- to post-test in the Attitude Toward Mathematics questionnaire

4.3 The value of the pilot study in this RCT

The pilot study in this RCT was of considerable value, as shown by the number of benefits derived from it.

The experience gained by the researcher while conducting the pilot study proved valuable both by giving him practice in undertaking an RCT, and by his gaining an understanding, leading to practical suggestions, as to how the research instruments themselves could be developed.

4.3.1 Personal lessons learned in connection to conducting an RCT in Saudi Arabia

4.3.1.1 The study requirements

One of the most important benefits of conducting the pilot study was that the researcher was able to recognise the issues that might be faced when conducting the main study and the requirements of doing such research in Saudi Arabia. These requirements include the paperwork required to do such research in Saudi Arabia, dealing with the research sample of both teachers and students, the kind of training needed for the teachers and students who would be participating in the main study and the best way of communicating with them. The researcher was able to establish the best way of addressing such issues as a result of his experiences in the pilot study.

4.3.1.2 RCTs as Saudi Arabia's future research methodology

Both teachers and students showed great interest in taking part in this study. They showed they were capable of undertaking the interventions and doing their best to take advantage of the methods used in learning and teaching mathematics, as was indicated by the researcher's observations, teachers' direct questions and students' indirect questions as sent by teachers. The researcher observed that teachers in Saudi are using a poor, ineffective teaching methodology, such as passive learning without interaction between teacher and students or among students, which reveals a real need to apply the interventions and train teachers in their use so as to raise their levels of performance. Improving teaching methodology can affect the students' learning of mathematics and enhance their attainments, attitudes and social relationships.

4.3.1.3 Developing relationships, and their role in education

The researcher established his own relationship to the Saudi education authorities, as is necessary for a successful experimental study such as an RCT, and developed his role as a researcher in education. During the pilot study, he began by establishing this relationship with the participating teachers and students, involvements which gave him new insight into many issues relating to the schools. Both the formal and informal conversations were valuable to the researcher's understanding of the current issues in education and in establishing the importance of conducting experimental studies in the public education sector in Saudi Arabia.

Once established, the relationships with the practical teachers gave the researcher fresh ideas about the real needs of both teachers and students if the educational standards of mathematical education in Saudi Arabia were to be improved, foremost among which was that teachers were in need of extensive training in the use of more active learning methods. Through the observational visits to schools, the researcher became a familiar face to students and grew to relate more closely to teachers. This gave him the opportunity to access the classrooms in the pilot study without disturbing the lesson, as both teachers and students felt comfortable with him in the classroom.

This whole social experience in the pilot study established its importance for the main study, particularly with regard to conducting the interviews in the latter. Teachers were more likely to raise questions, whether by phone or face-to-face, about issues they encountered when practising the interventions, and the researcher received many calls from teachers asking about points relating to their lessons for the following day. These calls were important to ensure the appropriate application of the interventions.

The researcher, therefore, noted the importance for the main study of building such relationships. During the pilot study, he also felt the significance of his role as an educational researcher working to improve education in Saudi Arabia and was very aware of the value and import of conducting experimental research, particularly RCTs, to the education community in Saudi Arabia.

4.3.1.4 The work with schools and the real issues faced by teachers and students

The researcher observed that the current methods used for teaching mathematics in Saudi Arabia were sufficiently poor to establish the significance of conducting experimental studies there. The observational visits in the classrooms during the pilot study told the researcher much about the teachers' and students' ability to participate in the RCT study and their willingness to improve mathematical education. It also clearly demonstrated a significant need for alternative learning methods in mathematics.

4.3.1.5 Working within a time limit

The researcher had to work to a strict timescale, while research participants, particularly teachers, had their own timetables and other work to attend to. Therefore, one of the most important skills that the researcher developed was time management, for which he used many strategies.

An organisational filing system, which will be discussed in more detail later in this chapter, was established to save time managing papers. Devising a visitation schedule was organisationally important, and as the main study samples were bigger and involved interviews with teachers and students within a single timescale, this schedule was very effective for the researcher. As discussed previously, the researcher's strong relationships with the teachers saved time as they made it easier to contact them via e-mail and phone as required.

4.3.2 Application of the pilot study outcomes to the main study

This research study benefitted in various ways from the pilot study: and this section will discuss the ideas suggested by its results.

The preliminary data collected through the pilot study suggested that the use of peer tutoring, with or without manipulatives, affected the students' learning of mathematics, which encouraged the researcher to continue the project and to extend the experiment to a large-scale sample, given the pilot's indication that it would be feasible, worthwhile and successful. The research protocol was tested through the pilot study, and the changes required for the main study, were identified, observed and taken into account, as were the logistical problems which could have arisen through using the proposed methods. Furthermore, the sampling technique was tested to establish its effectiveness for the research.

This section will discuss whether or not the main applications were changed as a result of the pilot study.

4.3.2.1 The study sample

The results of the pilot study suggested that fourth year students (aged 10-11) were a suitable choice, as stated in the research proposal. Students in that age range are capable of understanding the various learning techniques applied in this study. The change in the year 4 curriculum, as discussed in the methodology chapters, made this year the best choice for the study sample.

4.3.2.2 The intervention period

The pilot study results suggested that the period of time allocated for the implementation of the various learning techniques, which had to be long enough to test the students' attainments and their attitudes towards learning mathematics, fitted both the intervention and the financial budget and was therefore sufficient for the purpose of the study. Hence, the researcher decided to use the same timescale as he had used in the pilot study for the main study. However, as the other research instruments were not tested in the pilot study, this timescale could not apply to them.

4.3.2.3 Time limit per session

The researcher drew from the literature a proposed session length of 30 minutes. The time per session for the research groups was thus set at 30 minutes, once a week. The researcher used the 30-minute session time in the pilot study; and since the results of that study suggested that this was long enough for the purpose of the study, the decision was made to continue with 30 minutes per session for the main study intervention.

4.3.2.4 Research groups

The researcher decided to use four research groups for the final intervention, as used in the pilot study. The pilot study results suggested that there were differences between the various groups involved in this RCT, and those differences needed to be assessed in the main study.

4.3.2.5 The researcher training for the research processes

The researcher learned to improve the management and communication skills necessary to take the greatest advantage of the limited time available for the study, skills which helped him enlist the authority of the participating teachers and encourage them to strive willingly to be important and effective participants in the study. Among the most important skills to be developed were those of personal communication with teachers, and being able to answer their questions at almost any time of the day.

The researcher developed an organisational system necessary to manage the large quantity of paperwork generated, and to facilitate the smooth input of data to the SPSS. Each student had a file in which to keep all his tests and questionnaires. Each class had a larger file in which to keep all the students' files and each group had a box in which to keep the class files. This organisational system developed after the researcher felt the need for such system after the difficulties faced in managing the pilot study papers.

Managing the data in the SPSS - learning how to enter data into it, administer the necessary tests and report the results - were all lessons learned during the pilot study. The pilot study therefore comprised important practical training for the researcher's management of implications and analysis in the main study.

4.3.2.6 Instruments

The importance of conducting the pilot study had become obvious by the end of this RCT, as the researcher was able to identify more factors related to the intervention that should be observed, and developed the required instruments to assess these new factors. One such factor was the students' attitude towards their learning partner and another was the students' social relationship developments. The observational visits undertaken in the pilot study suggested that these two factors should be assessed in the main study, given their significance and the importance of their role in relation to the intervention. By including them, the researcher might further be able to examine whether or not the students' social relationships and attitudes towards their learning partners could predict their attainment scores.

One of the most significant benefits was the sense of the importance of using qualitative research methodology beside quantitative research methodology, as can be seen at the end of this RCT. In this case, undertaking interviews with teachers and students was very helpful in obtaining as much as in-depth information and explanations regarding the issues related to the intervention as possible.

The pilot study played a significant role in developing and testing the research instruments, and this section will give a brief idea of the effect of the pilot study on the development of these instruments.

Attainment Test

The researcher developed a criterion-referenced attainment test that focused on the mathematics units used in the pilot study. Although the test was piloted by a number of mathematics teachers, and 47 students took the test as a pilot group to assess its suitability, the reliability of the test was low (Cronbach's alpha 0.33 with a group of 47 Saudi Arabian students aged 11 years). Therefore, the researcher decided to search for another test. More information about the replacement test will be mentioned in Chapter Five (the methodology chapter).

Attitude of students towards mathematics

A 20-item questionnaire, to investigate changes in students' attitudes to mathematics during the study, was also administered. The questionnaire was translated and slightly adapted (to suit the context) from a questionnaire previously designed by Pell and Jarvis (2001). It was previously adapted for use in a mathematical context by Thurston et al. (2010). The reliability of the Arabic version was analysed (Cronbach's alpha 0.80 with a group of 39 Saudi Arabian students aged 11). Therefore, the researcher decided to continue using this instrument.

After further reading of the literature, and making observational visits to the classes involved in the pilot study, the researcher felt the importance of developing two more research instruments to examine the effect of using peer tutoring with or without manipulatives on both the students' attitudes towards their learning partners and the development of their social relationships.

The Attitude Towards Learning Partners questionnaire

The researcher decided to use a 20-item questionnaire to investigate changes in students' attitudes towards their learning partners during the study. The questionnaire was translated and slighted adapted (to suit the context) from a questionnaire previously used in a mathematical context by Thurston et al. (2012). More information can be found about this questionnaire in Chapter Five.

The Sociometric Questionnaire

The researcher decided to use, both before and after the experiments, a sociometric instrument that aimed to discover the effect of using peer tutoring and manipulatives, both separately and together, on the students' social relationships. More information on this questionnaire can be found in Chapter Five.

The qualitative data

The pilot study in the present thesis revealed the importance of evaluating the process used in the RCT in order to ensure the quality of the interventions, as suggested by Oakley et al. (2006) and Connolly (2009). Through the pilot study, the researcher decided to use qualitative methodology to obtain in-depth information on teachers' and students' perspectives of using peer tutoring and manipulatives, both separately and together, in learning mathematics. Both teachers and students were interviewed. In addition, the researcher decided to use observation visits to the classes concerned.

4.3.3 Sample size and effect sizes

One of the benefits of conducting the pilot study was the opportunity to calculate the initial effect size and sample size. These calculations helped the researcher to decide the size of the sample in the main study. However, other management factors were taken into account in making this decision such as the time scale and the research budget.

In conclusion, the pilot study was an effective part of this study with regard to developing research and personal skills, and helped the researcher to make important decisions regarding the implications of the study.

5 CHAPTER FIVE: RESEARCH METHODOLOGY OF THE MAIN STUDY

A mixed-method RCT was used to measure the effects of using peer tutoring and manipulatives, both separately or together on mathematical attainment, students' attitude towards mathematics, students' attitudes towards their learning partners and students' social relationship developments on the groups of students using them, as compared to a control group. In addition, the design of this mixed-method RCT included the teachers' and students' perspectives on using peer tutoring and manipulatives, both separately or together, on teaching and learning mathematics.

This chapter will present the research methodology of the main study. It will begin by describing the quantitative part of this RCT in section 5.1. It will then proceed to an explanation of the first and second qualitative parts of this RCT in sections 5.2 and 5.3, respectively.

5.1 The quantitative part of the RCT

This section will begin with the design of this part of the study. Then, the main study sampling will be discussed; the teaching condition in the main study; the main study research instruments; the study variables; the data collection schedule; and the data analysis.

5.1.1 Design of the quantitative part of the RCT

In the main study, the researcher decided to use the same design as in the pilot study. However, more research tools were used in the main study. A randomised controlled factor design was used to measure the effects of manipulatives, peer tutoring (PT), and peer tutoring combined with manipulatives on the groups using these, as compared to the control group. The following factors were examined: mathematical attainment, students' attitude towards mathematics, students' attitudes towards their learning partners and students' social relationship developments. Further information about the design of the study can be found in Chapter 4, section 4.1.2.

The researcher divided the classes to the same four groups in the pilot study; the control group, the manipulatives only group, the peer tutoring only group, and the peer tutoring and manipulatives together group.

In the main study the pre-tests were undertaken one week before the 12-week intervention and post-tests one week after it, both being 30-minute written tests administered by the participating teachers. More information on the interventions processes and testing regime is given in Chapter Three (the intervention chapter).

In the main study, the researcher continued to apply the interventions to grade 4 in elementary schools in AlAhsa, Saudi Arabia. More information on the reasons for choosing male students who study at grade 4, choosing AlAhsa city, and the teachers participating in the study can be found in Chapter Four (the pilot study chapter).

Two units of the fourth grade mathematics curriculum were chosen for the experiment. More information on the curriculum units can be seen in Chapter Three (the interventions chapter).

5.1.2 Sample

The researcher used the same sampling process that had been used in the pilot study. The schools that participated in this study were randomly assigned to conditions. The study involved 24 classes.

Further details of the sampling process can be found in Chapter Four, section 4.1.4.

Table 5-1 explains the study sample in detail:

Table 5-1: The main study sample

School code	School type	Class	Teacher code	Group	Number of students	Total number of students in school type	Total group
S01	ARAMCO	a	T01	1	36	110	203
S01	ARAMCO	b	T01	1	38		
S01	ARAMCO	c	T01	1	36		
S02	GOVERNMENT	a	T02	1	30	93	
S02	GOVERNMENT	b	T02	1	33		
S02	GOVERNMENT	c	T02	1	30		
S03	GOVERNMENT	a	T03	2	21	62	152
S03	GOVERNMENT	b	T03	2	19		
S04	ARAMCO	a	T04	2	31	90	
S04	ARAMCO	b	T04	2	29		
S04	ARAMCO	c	T04	2	30		
S05	GOVERNMENT	a	T05	2	22	62	
S06	ARAMCO	a	T06	3	27	81	143
S06	ARAMCO	b	T06	3	27		
S06	ARAMCO	c	T06	3	27		
S07	GOVERNMENT	a	T07	3	22	62	
S07	GOVERNMENT	B	T07	3	20		
S07	GOVERNMENT	C	T07	3	20		
S08	ARAMCO	A	T08	4	30	92	142
S08	ARAMCO	B	T08	4	30		
S08	ARAMCO	C	T08	4	32		
S09	GOVERNMENT	A	T09	4	14	50	
S09	GOVERNMENT	B	T09	4	14		
S05	GOVERNMENT	b	T05	4	22		
Total					640	640	640

Numbers assigned to each group:

1: control group.

2: manipulatives group.

3: peer tutoring group.

4: peer tutoring and manipulatives group.

5.1.3 Selection and training of teachers for the experiment

Detailed information on the selection and training of teachers and students is given in Chapter Three (the interventions chapter).

5.1.3.1 Sample size and effect size

The effect sizes in this research study were calculated using Glass, McGaw, and Smith's (1981: 29, 102) formula as cited in Cohen, Manion, and Morrison, (2011, p. 521). They calculate the effect size as:

$$\frac{\text{(mean of experimental group – mean of control group)}}{\text{standard deviation of the control group}}$$

The effect sizes of this research study were as follows:

The manipulatives group ES= 0.958

The peer tutoring group ES= 2.61

The manipulatives and peer tutoring together group ES= 3.079

The mean effect size of the intervention was 2.216. At 80% power and p=0.05; this indicated the sample sizes were sufficiently large to deduct effect at this level. The Daniel Soper sample size calculator indicated that the minimum sample size should have been five per group for a two-tailed t-test (Soper, 2014).

5.1.4 Implementation of peer tutoring and manipulatives, both separately or together, in the experimental groups and the implementation of traditional learning in the control group

Each classroom was provided with a 12-week pack that detailed the mathematics programme. Teachers were asked to use the programme once a week.

More information on the implementation of the interventions is given in Chapter Three (the intervention chapter).

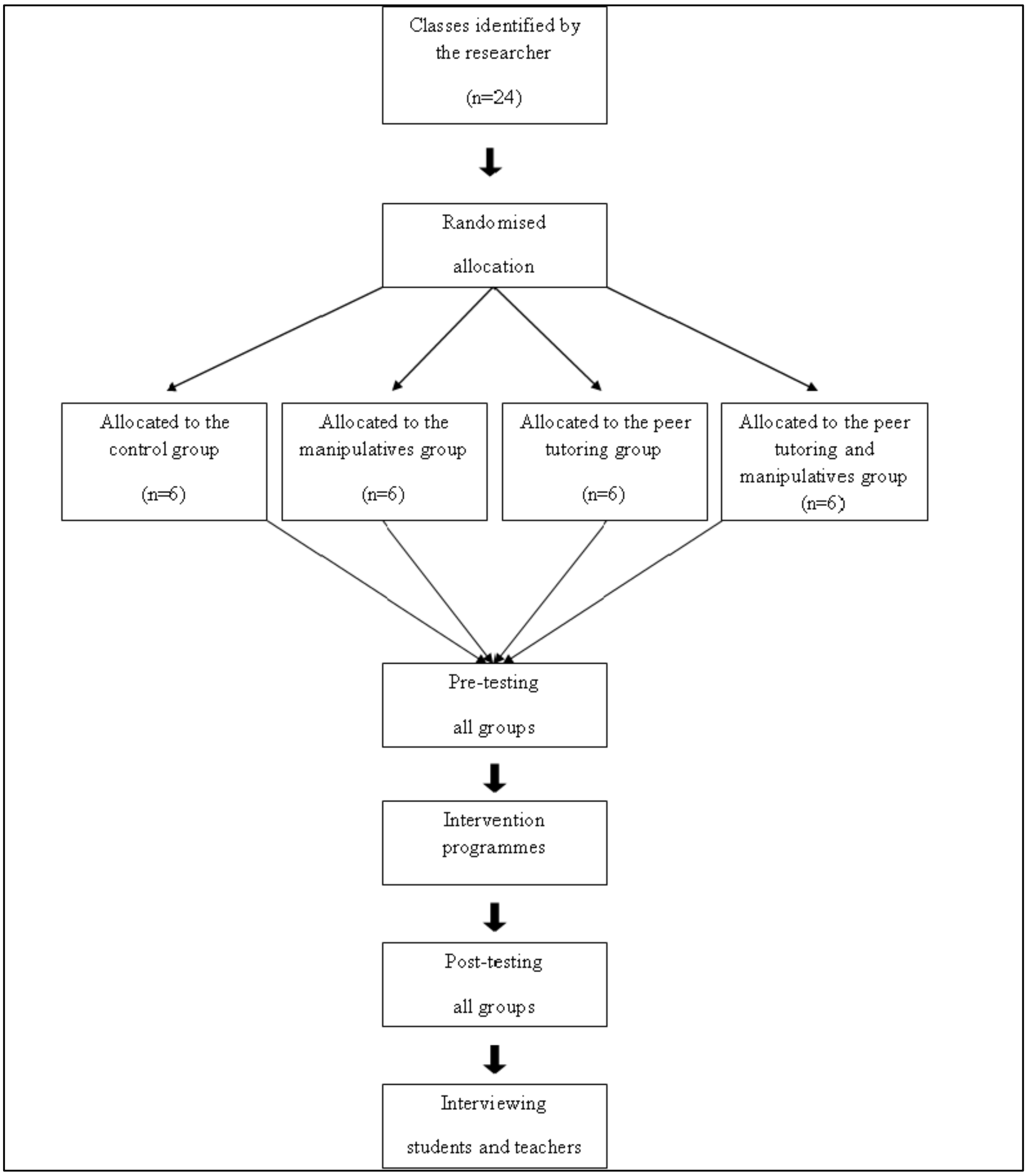

Figure 5-1: Selection and randomisation process

5.1.5 Teaching conditions

The researcher, school administrators and teachers had agreed to do the pre-test, the treatment, and the post-test in the same conditions, and all did their best to equalise all the factors (time of day and length of treatment) under the researcher's supervision.

Detailed information on the teaching conditions can be seen in Chapter Three (the interventions chapter).

5.1.6 Research instruments

5.1.6.1 Attainment test

As mentioned in Chapter Four (the pilot study chapter), the reliability of the test that was used in the pilot study was low (Cronbach's alpha 0.33 with a group of 47 Saudi Arabian students aged 11), so the researcher decided to search for another test. Each unit of the fourth year mathematics book has a test. The book's authors argue that each test has a strong reliability (Cronbach's alpha between 0.75-0.90). The researcher decided in this case to use the fourth year mathematics book tests for the two units selected in this study. A final version of the test was developed to ensure there were no ceiling and floor effects. A copy of the final test is included in the Appendices (see Appendix 1). All the 24 classes involved in this study took the test twice, once before the experiment and once after it. The test results were statistically analysed to discover if there was a statistically significant difference between the students' attainment before and after the use of peer tutoring and manipulatives, both separately and together. The SPSS programme was used to analyse the tests.

5.1.6.2 Attitude of students towards mathematics

The researcher used the same 20-item questionnaire 'Attitude Towards Mathematics questionnaire' that was used in the pilot study. Detailed information on the questionnaire can be seen in Chapter Four (the pilot study chapter).

5.1.6.3 Attitude of students towards their mathematics partners

A 20-item questionnaire to investigate changes in students' attitudes to their mathematics partner during the study was also administered. The questionnaire was translated and slighted adapted (to suit the context) from a questionnaire previously used in a mathematical context by Thurston et al. (2012). It was originally designed to measure the students' attitude towards their learning partners and its reliability was analysed (Cronbach's alpha 0.90). Students were asked to give their opinion on the statement using a five-point Likert scale, ranging from strongly agree (5 points) to strongly disagree (1 point).

The questionnaire had been piloted by a number of colleagues who worked in a variety of education departments in Saudi universities and a number of teachers. The reliability of the Arabic version was analysed (Cronbach's alpha 0.81 with a group of 203 Saudi Arabian students aged 11). A copy of the final questionnaire is included in the Appendices (see Appendices 4 & 5). Questionnaires were statistically analysed to see if there were any significant differences between the students' attitudes towards their mathematics partners before and after the use of peer tutoring and/or manipulatives. The SPSS programme was used to analyse and evaluate the questionnaires.

Thurston et al. (2012) conducted a principal component analysis on the Attitude Towards Learning Partner questionnaire, comprising the following five components:

- How tutors expected to work with their maths partners (Cronbach's alpha 0.87).
- The perception of their maths partners' cognitive ability in mathematics (Cronbach's alpha 0.87).
- The perception of the level of physical fitness and status of their learning partners (Cronbach's alpha 0.64).
- The perception of the behaviour standards of their learning partners (Cronbach's alpha 0.66).
- Their perception of the popularity of their learning partners (Cronbach's alpha 0.91).

The researcher used these factors to determine whether they could predict the students' attainment scores.

5.1.6.4 Sociometric instrument

In addition, a sociometric instrument that aimed to discover the effect of using peer tutoring manipulatives both separately and together on the students' social relationships was applied before and after the experiments. The researcher adapted the questionnaire from one designed by Thurston et al. (2012) and its reliability was analysed (Cronbach's alpha 0.79 with a group of 490 students aged 10, 11, and 12). It was similar to one used in the ScotSPRinG project and showed reliability (Cronbach's alpha 0.69) when used with 575 10- to 12-year-old students.

The instrument provided students with a list of classmates and a list of contexts in which they might like to see them both in and out of school, namely:

1. Like working with them during paired maths.
2. Like working with them in class.
3. Like working with them in other lessons.
4. Like being with them at school break-time.
5. Like being them with out of school.
6. Like being them with at the Masjed.

The students were required to place a tick next to the name of a student if they saw them in any of the above contexts. The reliability of the Arabic version was analysed (Cronbach's alpha 0.87 with a group of 203 Saudi Arabian students aged 11). A copy of the final questionnaire is included in the Appendices (see Appendices 6 & 7). Questionnaires were statistically analysed to see if there were any significant differences between the students' social relationships before and after the use of peer tutoring and/or manipulatives. The SPSS programme was used to analyse and evaluate the questionnaires.

5.1.6.5 Observational visits

The researcher applied the observational visitations as he did in the pilot study. More information and details on the aim of these visits and the methods of collecting data in are given in Chapter Three (the interventions chapter) and Chapter Four (the pilot study chapter).

5.1.7 Variables

All information on the independent variables, dependent variables, controlled variables and uncontrolled variables can be found in Chapter Four (the pilot study chapter).

5.1.8 Data collection

The table below shows the steps taken for the collection of study data.

Table 5-2: The main study schedule

Week	Start date	Job
1	5-3-2011	Finishing paperwork and choosing schools
2	12-3-2011	Meeting the teachers and the training courses Pre-test and pre-questionnaire for students, and first observation
3	19-3-2011	Worksheet (1)
4	26-3-2011	Worksheet (2)
5	2-4-2011	Worksheet (3)
6	9-4-2011	Vacation
7	16-4-2011	Worksheet (4)
8	23-4-2011	Worksheet (5)
9	30-4-2011	Worksheet (6)
10	7-5-2011	Worksheet (7)
11	14-5-2011	Worksheet (8)
12	21-5-2011	Worksheet (9)
13	28-5-2011	Worksheet (10)
14	4-6-2011	Post-test and post-questionnaire for students, and last observation.
15	11-6-2011	Interviews.

5.1.9 Analyses of the data

All the related data were analysed in order to test the study's hypotheses and assumptions. The data analysis procedure followed was the same as in the pilot study. For details, see Chapter 4, section 4.1.8.

5.2 Research methodology for the students' perspectives of using peer tutoring and manipulatives, both separately and together

This is the second methodology section in this RCT study. It discusses the research methodology of the first qualitative part of the main study, which discussed the students' perspectives of using peer tutoring and manipulatives, separately and together, in learning mathematics.

This section will begin with justifications for using a qualitative research method in this RCT. The justifications for using the case study approach in this part of the study will be discussed; the study sample for this part of the research; the method of the data collection; the method of data analysis that was used in this part of the study, and the ethical issues.

5.2.1 Justification for using a qualitative method in this study

The study question is:

What are the issues relating to the use of peer tutoring and manipulatives, either separately or together, in learning mathematics, from the perspective of elementary students in the city of AlAhsa, Saudi Arabia?

The main aim of this study is an exploration of these issues as perceived by the elementary-level mathematics students involved in this RCT.

Supplementary questions are as follows:

How do these students define these issues?

What do these students hold to be the benefits and constraints of using peer tutoring and manipulatives, either separately or together?

What are these students' experiences and beliefs concerning the use of manipulatives?

5.2.1.1 Justification for the proposed research

In pursuing the aim of this part of the study through both its main research question and its supplementary questions, the qualitative method emerges as the most appropriate one to use. All the questions aim to explore the students' perspectives. The research questions are not concerned with observing or establishing a theory, or testing a particular theory, nor do they aim to establish a relationship between cause and effect in this part of the study. Therefore, quantitative methods may not be always suitable for this type in this part of the study, whereas qualitative methods generally are when trying to explore such specific issues in depth.

However, according to Connolly (2009), in research studies investigating effectiveness, it can be difficult to identify the causes of these effects, and employing both a qualitative and a quantitative method may be necessary in order to design a robust study that can produce sound evidence and evaluate thoroughly the effectiveness of educational intervention. Therefore, use of both qualitative and quantitative methods at each stage allowed the questions raised in this study to be understood and addressed, identifying the specific outcomes which, in turn, helped to identify and develop the appropriate interventions.

As this study was a part of the RCT investigation detailed above the use of both a qualitative and a quantitative method was useful in establishing an in-depth understanding of the reasons given by students for the effectiveness of using peer tutoring, with or without manipulatives, in learning mathematics.

5.2.2 Justification for choosing the case study approach

Since the questions pursued by this study make it clear that the interest lies in pursuing deeper explanations and broader explorations of the issues, the case study emerges as the most appropriate type of qualitative research to use in this part of the study. This section will focus on the advantages of using this approach in this specific study.

As noted above, the case study is a type of qualitative method that is used to provide information from, and details of, one or more cases. This approach puts the case at the centre of the research inquiry, and focusing on it. Case studies can be useful if the research question seeks to understand ‘how’ or ‘why’, particularly when the study can be controlled (Yin, 1989). They can also be helpful if the inquiry seeks to generalise practical knowledge (Stake, 1995).

The case study has a number of advantages, the first being that it can help develop analytic and problem-solving skills which can be useful to the research community in terms of increasing awareness of community issues and an understanding of how to resolve them. There is considerable evidence to support this statement. In addition, it might allow for an exploration of possible solutions to complex issues. In the field of education, many such issues arise, particularly in relation to teaching theories and practical work. These issues can be particularly noted in studies relating to the teaching and learning of mathematics. Moreover, the case study can be helpful in allowing the research community to apply new knowledge and skills which may improve people’s lives. Many skills have been developed within the last decade through case study research. In the last few years, a number of researchers have used case studies to help them to answer their research questions and develop new knowledge and skills.

Therefore, the case study approach emerges as the best option for discovering and analysing teachers’ perceptions.

5.2.3 Sample

In the qualitative paradigm, there are two main techniques of sampling. The first is the random technique, where the researcher arbitrarily, or randomly, selects the research samples. In this technique, every member of the research population has an equal opportunity of being involved in the research process.

The second technique is non-random sampling. There are four types of non-random sampling.

The first type is convenience sampling, a non-probability sampling technique whereby subjects are selected for the convenience of their accessibility and proximity to the researcher. This can be used when researchers simply want to use the population sample closest to hand.

The second type is quota sampling, which can be used to find quotas of the population.

The third type is purposive sampling, which can be used when researchers need to find samples with similar characteristics, such as age group or gender.

The fourth type is snowball sampling. Researchers using this type of sampling try to find further participants by asking the first participants to identify others. However, in the qualitative paradigm, researchers mainly use the purposive technique in their sampling. They can use this technique in a number of ways, such as by selecting a small and homogeneous case, selecting typical or average cases, or selecting cases that are known to be very important (Johnson & Christensen, 2007).

This study used the random system, which means that each person in the study population had an equal opportunity to be involved in the study.

5.2.3.1 Study population

The study, the aim of which was to investigate the effect of using peer tutoring and manipulatives, either separately or together, in learning mathematics in elementary schools in AlAhsa, Saudi Arabia, was undertaken in AlAhsa, one of the largest cities in the Kingdom, and which has a number of elementary schools. The aim of this study was to investigate students' perspectives of issues surrounding the use of peer tutoring and/or manipulatives.

There were three experimental groups – peer tutoring, peer tutoring with manipulatives, and manipulatives alone - with six classes in each group. The nine students involved in the RCT study, three from each group, were selected from these 18 classes. These students were invited for interview and given the opportunity to express their ideas about the research topic and questions. The involvement in the interviews of students with a variety of different learning experiences gave the study greater validity.

5.2.4 Data collection

5.2.4.1 Description of the method of data collection used in this study

The method of data collection used in this study was the interview method: that is, an interviewer questioning an interviewee. Interviews can be divided into three categories. The first is the formal, or structured, interview, which is usually characterised by open-ended questions written in an interview protocol and asked in the precise order given in the protocol. The second category is the semi-structured interview, which is less structured than the formal interview; the interview protocol includes open-ended questions, an order for the questions is not required and the researcher can reword the questions if he/she thinks fit. The third category is the informal or unstructured interview, which is unplanned and does not have a protocol. The interviews can be conducted face-to-face or by telephone. Researchers can also use new technology such as MSN Messenger or similar resources (Johnson & Christensen, 2007).

One of the strengths of interviews is that they give the interviewer the opportunity to control the discussion, and help to access in-depth data and understand the thought patterns and processes of the interviewees.

Closed-question interviews can provide specific information needed for the research. By using telephone or e-mail researchers can save time and can enable access to people in different, distant locations.

By using interviews, a high level of reliability and validity can be ensured. Interviews can be used with probability samples. However, there are disadvantages in using interviews. They can be expensive; the answers given by the interviewees may be affected by the presence of the interviewer, particularly if there is already a relationship between them such as teacher and student; data can be left undiscovered if the interviewer does not have well-developed interviewing skills; once extracted, it can be lost if he does not have good data-recording skills and once compiled it takes time to be analysed (Johnson & Christensen, 2007).

5.2.4.2 Justification for choosing the interview method

This section focuses on the usefulness of the interview method in the dissertation case study. Using interviews has a number of advantages in this study, being one of the most frequently used methods in small-scale case studies (Drever, 1995). An interview can elicit a substantial amount of information, since the interviewees are all being interviewed voluntarily, and are therefore likely to answer all questions, and anything that is not understood can be explained (Drever, 1995). It may also provide opportunities to raise more questions during the interview which will help to investigate the case study more deeply. Furthermore, it can give the researcher a chance to appear more trustworthy, as in this instance: although the interviewer and interviewees met face to face, the latter were assured, and they trusted, that their identities would not be revealed. It also ranks highly in terms of validity and reliability. An increase in teachers' confidence is one of the most important benefits that may emerge as a result of involvement in these interviews.

5.2.4.3 The process of conducting the interviews

As these interviews were related to the study entitled 'Using peer tutoring and manipulatives to improve mathematics education in elementary schools in Saudi Arabia', the educational centre in AlAhsa city was informed about the study and the need to interview students within its authority. The researcher explained the purpose of the interviews; then, having obtained permission from the authority and the parents, students were randomly selected from the different groups. The students to be interviewed were individually contacted, informed of the aims of the research and given the right both to remain anonymous and to review the transcript of the interview. All students were interviewed face-to-face, and the interviews were recorded so they could be checked before being transcribed in Arabic, the language in which the interviews were conducted. They were then translated into English for the purpose of the research and analysed by the researcher.

5.2.4.4 The interview technique

There are different kinds of interview, and the semi-structured type appeared most suited to this study, as in this type of interview, questions can be flexible and can be raised as the researcher thinks fit during the interview.

First, an interview schedule attached in the Appendices (see Appendix 13) was drawn up, and checked and commented on by an independent expert before a final draft was prepared. The students were then interviewed. Each was asked relevant questions regarding the interview schedule, while further questions emerged, as this method allows the researcher to add to or alter those planned initially. These interviews were recorded.

5.2.5 Data analysis

5.2.5.1 Background

This section presents the data analysis. Quantitative data are usually analysed statistically, but qualitative data can be analysed in a number of ways. However, data analysis in quantitative research is generally a continual process. In some research contexts, it is called interim analysis. The process of collecting and analysing data continues either until the study questions are answered or until the research time or resources run out (Johnson & Christensen, 2007).

The researcher analyses the transcripts in detail and makes notes of what has been learned from the collected data, which can then be categorised into units, each unit being given a symbol or name – that is, a code – which should be listed (Johnson & Christensen, 2007).

There are two types of coding: in the first, priori codes, researchers develop codes before reading the data, while in the second, inductive codes, researchers develop the codes during the reading of the data. Researchers may need to use co-occurring codes - that is, codes that need to be established when researchers find more than one code attached to the same line of data. They may also need to make factsheet codes, which are codes, each of which applies to a specific participant in the study, and which are used when researchers are interested in individual characteristics. The researcher is then ready to summarise the data (Johnson & Christensen, 2007).

The data can then be enumerated, which means that the researcher can, for example, count words or codes that are repeated. This can be important in helping the researcher when writing the report, and to give more meaning to words referring to numbers in the report. At this point, the researcher can analyse the data using different kinds of tables, diagrams, typologies and hierarchical categorising systems (Johnson & Christensen, 2007).

5.2.5.2 Thematic content analysis

Burnard (1991) outlined a method of data analysis which he designated thematic content analysis. The full transcripts of the semi-structured interviews are the main resources of the data analysis in this method (Burnard, 1991). The data should be categorised and coded for later use, and the researcher should then verify the validity of the process and the data (Burnard, 1991).

In this case study, the processes of Burnard's thematic content analysis method were followed to analyse the data collected, explore the material thoroughly and explain it. Then the data from the interviews was categorised. As Burnard (1991) states, this method allows the researcher to describe and put the data in order. In this case study, the perceptions of the mathematics students who participated in the interviews were explored.

As can be seen, this method helps the researcher to follow a clear procedure for analysing the data. In addition, the validity of the data can be ensured during the analytical processes, which benefits the researcher in such matters as time management and monitoring the funding step by step, advantages that both support the researcher and indicate the appropriateness of the method for use in this case study.

In addition, Brenner (1985) suggested the following thirteen steps when undertaking content analysis:

1. Briefing: understanding the problem and its context in detail.
2. Sampling: of people, including the types of sample sought (see Chapter 4).
3. Associating: with other work that has been done.
4. Developing a hypothesis
5. Testing the hypothesis.
6. Immersing in the data collected, to pick up all the clues.

7. Categorizing: in which the categories and their labels must reflect the purpose of the research, be exhaustive and be mutually exclusive.

8. Incubating: reflecting on data and developing interpretations and meanings.

9. Synthesizing: involving a review of the rationale for coding and an identification of the emerging patterns and themes.

10. Culling: condensing, excising and even reinterpreting the data so that they can be written up intelligibly.

11. Interpreting: making meaning of the data.

12. Writing: including giving clear guidance on the incidence of occurrence; proving an indication of direction and intentionality of feelings; being aware of what is not said as well as what is said - silences: indicating silence to the readers and respondents.

13. Rethinking. (as cited in Cohen, 2007, P. 369).

5.2.5.3 The processes of thematic data analysis

After undertaking each individual interview in depth, detailed notes were made. Then, each transcript was allocated a code. A final list of the codes was drawn up, following which independent categories were made and adjusted by education experts. Finally, the emerging issues were compared with the identified issues.

A new document was made relating the interviews to the relevant experimental group (peer tutoring, peer tutoring with manipulatives, and manipulatives alone). The researcher then reviewed the whole, verifying the content and comparing it with the original transcript to check whether the questions related to their sections or not. This process ensured the validity of the data.

5.2.5.4 Analysis framework

By using Burnard's (1991) method, the researcher was able to highlight the main issues relating to the case study. In addition, the validity of the data was ensured at every stage of the process. The involvement of education experts throughout the processes was a further great advantage.

5.2.6 The ethical issues

5.2.6.1 The issue of confidentiality

In order to assure a high level of confidentiality, all the interviewees were guaranteed anonymity in case the information might be needed in the future. Each was given an identifying code known only to the interviewee and the researcher. In addition, all tapes and transcripts were safely stored in a locked cupboard to which only the researcher had the key. All volunteers had participated in the interviews on the understanding that they had a right to have a copy of their tapes and transcripts, to review them and to correct any errors. They had been instructed not identify themselves during the recordings.

5.2.6.2 The ethical approval

The participants were given opportunities throughout the sampling procedure to consider whether or not they wanted to take part in this study. The ethical approval required by the University of York was observed in detail to ensure that all the ethical issues relating to this study were addressed and adhered to.

5.3 Research methodology for the teachers' perspectives of using peer tutoring and manipulatives, both separately and together

This is the third methodology section in this RCT study. It will discuss the research methodology of the second qualitative part of the main study, which considered the teachers' perspectives of using peer tutoring with or without manipulatives in teaching mathematics.

5.3.1 Justification for choosing a qualitative research method

The main aim of this part of the study is to explore the issues surrounding the use of peer tutoring and manipulatives, both separately and together, as perceived by elementary-level mathematics teachers involved in this RCT.

There are limitations to using an RCT in order to evaluate an intervention programme. Therefore, Connolly (2009) suggested employing both quantitative and qualitative research methods. Qualitative research gives more in depth information around the interventions that gives the assessment of the interventions greater validity. This information can provide a clear vision of what teachers noticed around the used interventions and explain their perspectives around the advantages and disadvantages of applying the interventions. This qualitative part of the study was carried out to investigate the issues relating to the use of peer tutoring and manipulatives in mathematics teaching from the perspectives of elementary mathematics teachers in the city of AlAhsa, Saudi Arabia. Furthermore, it is recommended that an evaluation process be conducted to evaluate the interventions when doing RCTs. In this light, this part of the study is one of the evaluation processes of the interventions.

The main research question is:

What are the issues relating to the use of peer tutoring and manipulatives in mathematics teaching from the perspectives of elementary mathematics teachers in the city of AlAhsa, Saudi Arabia?

<u>The supplementary questions are as follows:</u>

How do these teachers define these issues?

What do these teachers state are the benefits and constraints of using peer tutoring with or without manipulatives?

What are these elementary mathematics teachers' experiences and beliefs concerning the use of peer tutoring with or without manipulatives?

In what ways are these teachers' uses of peer tutoring with or without manipulatives influenced by education policies?

In pursuing the aim of this study through its main research question and its supplementary questions, a qualitative method emerged as the most appropriate. All the questions aim to explore the teachers' perceptions. The research questions are not concerned with observing or establishing a theory, or testing a particular theory, nor do they aim to establish a relationship between cause and effect. Therefore, quantitative methods may not be useful for this type of study, whereas qualitative methods are usually appropriate when trying to explore such specific issues in depth.

As this study was a part of the RCT investigation detailed above, the use of both a qualitative and a qualitative method was useful in establishing an in-depth understanding of the reasons given by teachers for the effectiveness of using peer tutoring, with or without manipulatives, in teaching mathematics. This agrees with what Connolly (2009) stated concerning the importance of employing both a qualitative and a qualitative method, as this may be required in order to design a robust study that can produce sound evidence and thoroughly evaluate the effectiveness of educational intervention studies.

5.3.2 Sample

This part of the study will use the non-random system of sampling as all teachers from the experimental groups were interviewed.

5.3.2.1 Study population

The study, the aim of which is to investigate the effect of using peer tutoring and manipulatives, either separately or together, in teaching mathematics in elementary schools in the governorate of AlAhsa, Saudi Arabia, was undertaken in AlAhsa.

There were three experimental groups – peer tutoring, peer tutoring with manipulatives and manipulatives alone – with six classes in each group. The nine teachers involved in the RCT study, three from each group, were interviewed. These teachers were invited for interview and given the opportunity to express their ideas about the research topic and questions. The involvement in the interviews of teachers with a variety of teaching experiences enhanced the validity of the study.

5.3.3 Data collection

5.3.3.1 Description of the method of the data collection used in this part of the study

The researcher used the same method of the data collection as used in the first qualitative part of this RCT (the students' perspectives) which is the semi-structured interview.

More information on this method of data collection can be found in section 5.2.

5.3.3.2 Justification for choosing the interview method

As this is one of the qualitative parts of this study, a semi-structured interview was used to collect the data. More information on the advantages of using the semi-structured interview in such research can be found in section 5.2.

5.3.3.3 The process of conducting the interviews

As these interviews related to the RCT in which teachers were involved in the interventions, the educational centre in AlAhsa city was informed about the study and the need to interview teachers within its authority. The researcher explained the purpose of the interviews; then, having obtained permission from the authority, all the teachers involved with the experimental groups were interviewed. They were contacted individually, informed of the aims of the research and given the right both to remain anonymous and to review the transcript of the interview. All teachers were interviewed face-to-face, and the interviews were recorded so they could be checked before being transcribed in Arabic, the language in which they were conducted. They were then translated into English for the purpose of the research and analysed by the researcher.

5.3.3.4 The interview technique

There are different kinds of interview, and the semi-structured interview seemed to be the best type for this study, as its questions can be flexible and more questions can be raised as the researcher thinks fit during the interview.

First, an interview schedule (see Appendix 12) was drawn up, checked and commented on by an independent expert before a final draft was prepared.

The teachers were then interviewed. Each was asked relevant questions from the interview schedule, while further questions emerged, as this method allows the researcher to add to those planned initially. These interviews were recorded.

5.3.4 Data analysis

5.3.4.1 Background

Detailed information on the background of the interview data analysis can be found in section 5.2.

5.3.4.2 Thematic content analysis

The processes of Burnard's (1991) thematic content analysis were followed to analyse the data collected, explore the material thoroughly and explain it. Then the data from the interviews were categorised. As Burnard (1991) states, this method allows the researcher to describe and put the data in order. In this case study, the perceptions of the mathematics teachers who participated in the interviews were explored.

As can be seen, this method helps the researcher to follow a clear procedure in analysing the data. In addition, the validity of the data can be ensured during the analytical process, which benefits the researcher in such matters as time management and monitoring the findings step-by-step, advantages that both support the researcher and indicate the appropriateness of the method for use in this case study.

In addition, Brenner's (1985) thirteen steps (see section 5.2) were followed when undertaking content analysis:

5.3.4.3 The processes of thematic data analysis

After undertaking each individual interview, in-depth detailed notes were made. Then, each transcript was allocated a code. A final list of the codes was drawn up, following which independent categories were made and adjusted by educational experts. Finally, the emerging issues were compared with the identified issues.

A new document was made relating the interviews to the relevant experimental group (peer tutoring, peer tutoring with manipulatives and manipulatives alone). The researcher then reviewed the whole, verifying the content and comparing it with the original transcript to check whether the questions related to their sections or not. This process ensured the validity of the data.

5.3.4.4 Analysis framework

By using Burnard's (1991) method, the researcher was able to highlight the main issues relating to the case study. In addition, the validity of the data was ensured at every stage of the process. The involvement of education experts throughout the processes was a further great advantage.

5.3.5 The ethical issues

5.3.5.1 The issue of confidentiality

In order to assure a high level of confidentiality, all the interviewees were guaranteed anonymity in case the information might be needed in the future. Each was given an identifying code known only to the interviewee and the researcher. In addition, all tapes and transcripts were safely stored in a locked cupboard, with the key held only by the researcher. All volunteers had participated in the interviews on the understanding that they had a right to have a copy of their tapes and transcripts, to review them and to correct any errors. They had been advised not to identify themselves during the recordings.

5.3.5.2 The ethical approval

The participants were given opportunities throughout the sampling process to consider whether or not they wanted to take part in this study. The ethical approval required by the University of York was observed in detail to ensure that all the ethical issues relating to this study were addressed and adhered to.

5.4 Research methodology for the fidelity checks of the interventions groups and the control group

The purpose of the observations, the frequency of visits to classes and how these were decided, as well as the format the observations took, are all described in detail in Chapter 3.

6 CHAPTER SIX: THE RESULTS OF THE MAIN STUDY

A variety of research methods were used in this mixed-method RCT and therefore, the results of both the quantitative and the qualitative parts of the study will be presented in this chapter. The rate of attrition did not exceed 5.5% in any condition for any of the instruments. This rate is considered too low to affect the results of the study and therefore there were no implications from this.

This chapter is structured as follows. Section 6.1 will describe the effect on attainment of the application of peer tutoring and manipulatives, both separately and together. This will include the quantitative and qualitative data relating to the academic outcomes. In Section 6.2, the affective outcomes of using peer tutoring and manipulatives, both separately and together, will be described. This includes the quantitative and qualitative data relating to the affective outcomes. The regression analysis of the data will be presented in Section 6.3. The chapter ends with Section 6.4, which describes the procedure used for the fidelity check.

6.1 Effect on attainment

6.1.1 Maths Attainment Test

The data indicated that there were significant gains in the mean score in each condition.

The combined peer tutoring and manipulatives group had the greatest change as the mean of its pre-test score was 3.53 (*SD* 1.65) and the mean of its post-test score was 17.07 (*SD* 2.48).

The mean effect size of the intervention was 2.216. At 80% power and p=0.05 this indicated the sample sizes were sufficiently large to deduct effect at this level. The

Daniel Soper sample size calculator indicated that the minimum sample size should be five per group for a two-tailed t-test (Soper, 2014).

Table 6-1: The mean and standard deviation of the pre-test, post-test, change (pre-post) and the effect sizes upon the different groups involved in the study in the Attainment Test

Group code	1	2	3	4
Group name	Control	Manipulative	Peer tutoring	Peer tutoring and manipulatives
Number of students	(n=202)	(n=147)	(n=135)	(n=138)
Number of classes	6	6	6	6
Pre-test	2.58 (2.04)	3.65 (2.86)	3.07 (1.55)	3.53 (1.65)
Post-test	7.7 (3.43)	11.39 (3.51)	15.33 (2.53)	17.07 (2.48)
Pre-post (change)	5.12 (3.47)	7.74 (4.15)	12.26 (2.55)	13.54 (2.76)
Effect size		0.958	2.61	3.079

Analysis indicated that the pre- and post-tests in each condition were normally distributed and therefore pre- post-test differences within condition were analysed using the two-way repeated measures ANOVA.

A two-way repeated measures ANOVA was conducted to assess whether the differences in pre- post-test scores were significant in the conditions.

The results revealed that the post-test mean scores were significantly higher than the pre-test mean scores within conditions: $F(3,613)= 221.617$, $p< .001$, partial $ή^2$ = .520. The interaction is displayed in Figure 8-1, showing a positive slope from the pre- to post-tests in all groups. Therefore, paired-sample *t*-tests were conducted to assess whether the differences from the pre- to post-test scores were significant in all groups.

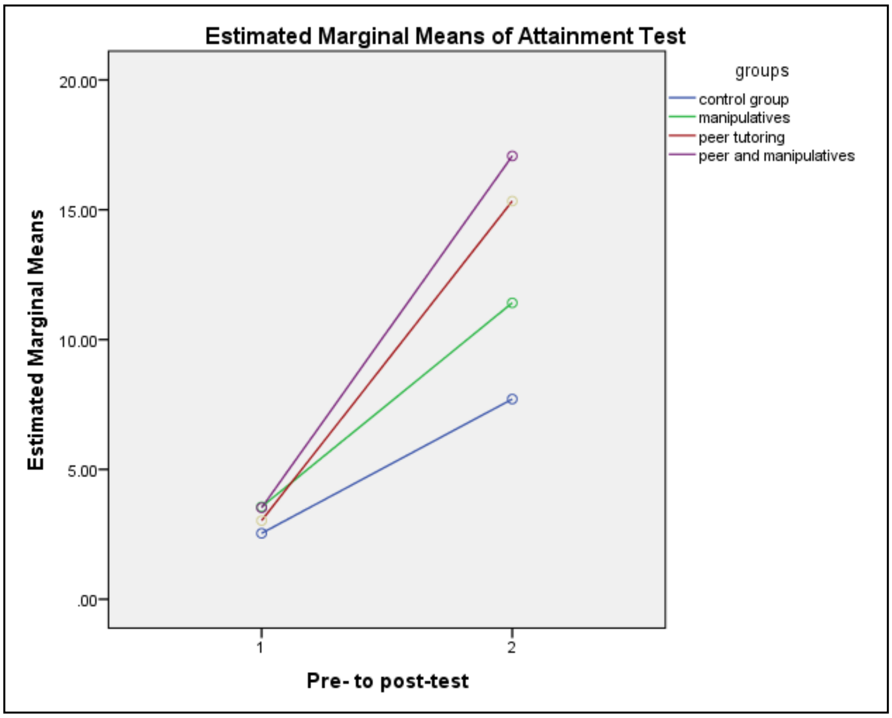

Figure 6-1: The changes in the mean scores from the pre- to the post-test in the Attainment Test

The paired-samples *t*-test showed that the differences between the students' pre-test attainment scores and their post-test attainment scores were significant in each condition; the control group (t (197) = - 20.904, $p < 0.001$), the manipulative group (t (147) = - 22.939, $p < 0.001$), the peer tutoring group (t (135) = - 55.958, $p < 0.001$) and combined manipulatives and peer tutoring group (t (138) = - 57.772, $p < 0.001$).

The results of the two-way repeated measures ANOVA revealed that when the pre- and post-tests were combined there were significant differences between the groups: $F(3,613)= 203.833$, $p< .001$, partial $\acute{\eta}^2 = .499$.

The three-way, between-subjects analysis of variance (ANOVA) is a statistical test that is usually used to compare the means between groups. It helps to decide if any of those means are significantly different from each other.

Therefore, a three-way, between-subjects ANOVA with Bonferroni *post-hoc* test was conducted on the differences between the students' scores in the Attainment Test to compare the differences between conditions. The results of the three-way ANOVA test revealed that there were significant differences between groups: $F(3,613)= 221.617$, $p< .001$, partial $ή^2 = .520$.

These differences were statistically significantly higher in the experimental groups than the control group, i.e., in the manipulatives group ($p< 0.001$), the peer tutoring group ($p< 0.001$) and the combined peer tutoring and manipulatives group ($p< 0.001$).

Within experimental groups, the differences between the students' mean scores in the mathematics Attainment Test were statistically significantly higher in both the peer tutoring only group ($p< 0.001$) and the combined manipulatives and peer tutoring group ($p < 0.001$) than in the manipulatives group. The differences between students' mean scores in the mathematics Attainment Test were significantly higher in the combined manipulatives and peer tutoring group than those for the peer tutoring group ($p= 0.012$).

6.1.2 Students' perspectives

Students in the manipulatives group reported that using manipulatives could help them in understanding their mathematics better. One student expressed the views of many, saying *"I understood mathematics much better when my teacher used manipulatives."* The students gave two reasons for this better understanding. The first reason was that manipulatives helped them establish a link between the theories and their practical application. *"Manipulatives always help me to understand mathematical theories and how to use them to solve problems,"* maintained one. Manipulatives can also help to explain abstract mathematical ideas, make them more understandable and show students the links between what they learn in mathematics lessons and what they experience in real life. One stated, *"They help us by showing how theory can be translated into practical applications in real life."*

The second reason was that manipulatives explained in simple terms ideas that might otherwise seem complicated. As one student observed, *"They help my teacher to clarify complicated ideas."* They can also help students reach a deeper understanding of mathematical subjects. One remarked, *"Using them helps me to gain a deeper understanding of how to solve fractions."* Manipulatives can also help to recall the process of doing maths. As another realised, "*After using them I can recall the process of doing maths faster by remembering the way my maths teacher used manipulatives."*

On the other hand, students highlighted a number of academic disadvantages to using manipulatives in learning mathematics, one being that some find them difficult to understand. *"I could not understand how they work,"* confessed one. *"I do not like using them at all."* This disadvantage can lead to another, namely confusion. As a second student admitted, *"They always confuse me."* Furthermore, a number of students agreed that manipulatives would distract them from focusing on the main subject. One spoke for them all, saying, *"I do not need this stuff. It is annoying to me."* Some of these students stated that it was not the manipulatives which annoyed them but the volume of noise made by other students using them. As one put it, *"I cannot focus; it is too noisy when other students are using them."*

Students in peer tutoring group reported a number of academic effects resulting from using peer tutoring in their mathematics.

Firstly, they asserted that they had a better understanding of mathematics with remarks such as, *"At the beginning of using peer tutoring I thought I understood better when things were explained by the teacher, but now I find I understand better when I cooperate with my partner."* They gave two reasons for this. One was that their partners were actively helping them to understand the questions, which positively affected their abilities in solving maths problems; or, in the words of one student, *"My partner is helping me to understand the question, so I am able to solve it."* The second was the recognised benefit of discussion with their partner.

Furthermore, students felt more actively engaged in the learning process: as one summarised the thoughts of many, *"Peer tutoring learning makes me an active learner."*

Students also described the development in their learning skills. For example, they said they were now discussing ways of resolving mathematical problems which involved coaching and guiding each other to work out answers, rather than just giving answers.

They said they felt more encouraged to learn mathematics when peer tutoring took place in class, and that social relationships with the other students and with teachers were the cause of that encouragement. As one said, *"My good relationship with other students and with my teacher encourages me to learn."*

They also stated that they now wanted to spend more time learning mathematics since they enjoyed it so much, saying they would like to have more maths lessons each week; and they started to learn mathematics everywhere inside and outside the school. A typical statement was, *"I would like to have more maths lessons, I enjoy myself so much."*

Moreover, students stated that they were obtaining even more benefit when they played the role of the teacher (as tutor) during peer tutoring than when they played the student role. As one said in his interview, *"I get more advantages when I teach my partner, as I understand things better and more thoroughly now I am more skilled."*

The students in the joint manipulatives and peer tutoring group identified a number of resulting academic effects on their learning of mathematics.

Students felt they understood mathematics better when using both manipulatives and peer tutoring. For instance, one stated, *"Manipulatives and peer tutoring together clearly make mathematical ideas easier to understand."* They attributed this better understanding to three reasons. To start with, their partners helped them to understand the questions better, positively affecting their ability to solve mathematical problems. Secondly, they simply talked with their partners, while the third is that coupling manipulatives with peer tutoring makes it easier to address and formulate abstract ideas. As one summarised it, *"It was so difficult to understand some ideas in mathematics - they were a mystery to me, but with peer tutoring using manipulatives they are much easier to grasp."*

Students also said they were more actively involved with their learning. Said one, *"We have become increasingly actively involved after manipulatives were used together with peer tutoring."*

Students also recognised their developing learning skills. For example, they began to discuss ways of resolving mathematical problems without giving each other the answers.

They said they felt more encouraged to learn when they used manipulatives and peer tutoring together in class, and that their improved social relationships with other students and with their teachers were the reasons for that encouragement. *"I feel more encouraged to learn mathematics because of my classmates and our newly improved relationships."*

They now liked to spend more time learning mathematics because they were enjoying it, stated that they would like to have more maths lessons each week and started to do mathematics everywhere, inside and outside the school. One spoke for them all when he said, "*Actually, we enjoy maths so much now that I wouldn't mind* *even having more maths lessons, if our timetable allowed it. Sometimes we even play maths games and learn some more maths in our free time."*

Moreover, students stated that they benefited more when they played the role of teacher rather than student during peer tutoring. As one of the students who were interviewed stated, *"I get more benefits when I teach my partner than vice versa."*

6.1.3 Teachers' perspectives

Teachers in the manipulatives group reported that they were satisfied with their achievements as they observed the effects of their performances on the students. Teacher I01 stated, *"Of course it is positive, as far as I am concerned, when I feel that the students have understood the subject and answered questions on it. This is a positive effect…"*

The use of manipulatives may, paradoxically, reduce the teacher's role in the teaching process while yet enhancing that role and making it more effective. For example, Teacher I03 stated, *"The students understand through using these. I mean, the first thing is that they take less time, and you can convey the information to the pupil more easily."*

Taking less time affected the teachers' performance in a positive way, since this gave them opportunities to spend more time interacting with their students. Teacher I02 stated, *"…in the long run, they do save time as less time is needed for explanation in the following lessons."*

They also stated that using manipulatives meant they needed to make less effort when teaching mathematics. Teacher I03 stated, *"Teachers like to use these scientific methods, including manipulatives, to save a lot of time and effort."*

Manipulatives helped teachers to work with students of different abilities. As Teacher I03 realised, *"Manipulatives can be used with the excellent students, the very good, the average and the weak students at the same time…"*

Manipulatives can also help teachers to explain and clarify facts. As Teacher I02 observed, *"Manipulatives can help to explain facts. I mean, when students have practical, hands-on equipment to use, the maths is easier for them and they can grasp it more quickly and easily.* Teacher I01 was among those who recognised that manipulatives were useful in starting their lessons well: *"Teachers should start the lesson by giving the students the specified manipulatives for the task in hand…"* Manipulatives helped teachers to create an active environment. As Teacher I03 said, *"Students can be inspired by their environment and here they will be surrounded by an active environment."*

Manipulatives helped the teachers to explain abstract mathematical ideas and make them more understandable. Said Teacher I02, *"…abstract concepts can be easily understood and learned..."*

Teachers reported that manipulatives helped them to show their students the links between what they learned in mathematics lessons and what they saw and experienced in real life. Teacher I02 continued, *"...it helps the students by showing how theory can be translated into practice, in real life ..."* Furthermore, the use of manipulatives gave the teachers more opportunities to communicate with their students and make the lessons more fun. As they saw it, it helped them to foster good relationships with their students. In the words of Teacher I02, *"They help me to communicate better with the students and enable them to reach a clearer understanding of the ideas I am trying to explain."*

On the other hand, there were some negative influences on the teachers' performances when they used manipulatives. For example, they can be time-consuming if teachers use them ineffectively. As Teacher I01 observed perceptively, *"If you do not have the knowledge to use them, they can waste teachers' time."*

Regarding their students' academic progress, teachers from the manipulatives group reported that the use of manipulatives in teaching renders mathematical concepts clearer and more understandable. As Teacher I01 observed with some surprise, *"... manipulatives were actually amusing, for the students and for me, as I conducted the lesson. They worked well. The students understood well..."*

The use of manipulatives can help students to reach a deeper understanding of mathematical subjects and concepts, as Teacher I02 realised when he wrote, *"You could clearly see that in lessons in which manipulatives were used, the students' understanding was well established."*

Manipulatives helped students to make links between theory and practice, and between pure, abstract mathematics and its application to real life situations. *"Manipulatives are realistic and practical,"* remarked Teacher I02.

On the other hand, the use of manipulatives negatively influenced students' performance at times by distracting their attention. Teacher I03 reported that *"…they say that the preparation, introduction and use of the manipulatives distracts them from their work."*

Teachers from the peer tutoring group reported that the use of peer tutoring affected the teachers' performances in different but positive ways, and clearly felt it made them more confident. Teacher I04 felt he was able to *"perform better after using peer tutoring,"* a view almost exactly replicated by Teacher I06: *"I feel more confident when I use peer tutoring. My students understand better."* They all gave peer tutoring as the reason for their students' better understanding and performance in class.

Teachers acknowledged that peer tutoring encouraged them to develop their teaching skills. They started to read more about the modern teaching methods and learning theories and to look for more training courses in teaching skills. Teacher I04 spoke for a number of them when he said, *"After using peer tutoring I am open to developing my teaching skills."* Teacher I05 confirmed this view, saying, *"I am now up to take more training courses in teaching and learning methods."*

Moreover, teachers seemed to be satisfied that the active participation of students in the classroom improved when using peer tutoring, citing two-fold reasons for this. They themselves needed to make less effort than before, because the manipulatives did some of the work for them, and students would and could explain ideas to each other in ways they understood. Teacher I06 stated, *"My role in the classroom has decreased, and I am happy with that as my students explain things to each other."*

They also found that peer tutoring was very helpful in managing their time in the classroom, saying that when they started to use it they felt they needed less time to explain things to students. They felt this was because students used the time both in and out of the classroom to explain mathematical ideas to each other. Teacher I05 noted with satisfaction, *"I am saving time as my students do my job for me by explaining to each other when they do not understand."*

Teachers felt that peer tutoring helped them to establish an active learning environment in the whole school, and not just the classroom; the whole school became alive. Teacher I05 summarised it thus: *"My students are learning with each other everywhere inside the school. I see them learning mathematics in their free time and they feel free to ask me for help at any time."* Teacher I06 supported this. *"My students influenced students from other classes and grades and they encouraged other students to learn with each other,"* he said, adding, *"My students established a social learning group in the school with the aim of helping each other with their mathematics. They asked me to help them when they needed it."* He continued, *"This experience enhanced and affected students with different abilities and increase all students' performances. It is like magic."*

Using peer tutoring seemed to affect the teachers' attitude to teaching mathematics. They found they enjoyed their work and the interaction with their students much more than before. *"Now my classroom has become more alive, I really enjoy teaching mathematics,"* said Teacher I04 with satisfaction, while Teacher I06 echoed his sentiments with, *"I like teaching mathematics now more than before and even enjoy spending more time on lesson preparation."*

Teachers from the peer tutoring group stated that peer tutoring had positively affected their students' academic performance, and that they understood mathematical concepts better since its introduction into lessons. Teacher I04 confirmed that his students *"... were more able to understand mathematical concepts."* Teachers also reported that students had a deeper understanding of mathematics as evidenced in the way they now solved problems and explained to other students how to do this. Teacher I06 said with satisfaction, *"My students understand mathematics much more thoroughly than before; they are better at their own maths and, interestingly, they can also explain it intelligently to other students."* They noted that their students did better in mathematics exams since peer tutoring was used. Teacher I06, for example, was justifiably proud of his students' results, saying, *"My students did better in exams than those in other classes."* Students were also seen to be using free time at school to learn mathematics with each other. Teacher I06 reported with some amusement, *"My students vie with each other in friendly competition to see not only who can do maths better themselves but also who can explain it better to others."*

Using manipulatives and peer tutoring together was reported by teachers to have affected their own classroom performances positively and satisfyingly. As Teacher I08 stated, *"I am teaching better after using both manipulatives and peer tutoring."* Furthermore, they were more confident, as Teacher I09 explained: *"I am more* *confident about my teaching since introducing manipulatives and peer tutoring."* They felt this resulted from students' better understanding and performance in class. Not only that, but teachers seemed to feel encouraged to develop their teaching skills further after using manipulatives and peer tutoring. They said they felt motivated to read more about modern teaching and learning theories and methodologies, and were more willing to take training courses in teaching and learning. For instance, teacher I07 stated, *"I would love to develop my teaching skills and it would be nice to try out new teaching methods. I will indeed look for training courses."*

Teachers recognised that the use of manipulatives with peer tutoring increased the participatory role of students in the classroom - in other words, it made them more active learners - and that they benefitted from that in two ways: teachers needed to be less actively involved in the actual learning process than before, because their didactic roles in the classroom had contracted, and students were able to explain ideas to each other in ways they clearly understood. Teacher I09 reported with evident satisfaction, *"My students are now helping me in my teaching as they explain maths to each other, so I am able to stand back from the learning process."*

As a result, teachers were able to manage their time in the classroom more effectively since the help students were giving each other meant that the teachers needed less teaching time to cover the same work. Teacher I08 stated, *"My students actually save class time by teaching each other."*

Active learning environments were established in the schools through the use of manipulatives and peer tutoring together, with teachers reporting a number of events where students were using manipulatives to explain mathematical concepts socially to each other in their own time. Teacher I08 noted, *"I have often seen my students using manipulatives to teach each other in their own time."* This behaviour encouraged students from other classes and grades to do the same. *"I am amazed that* *my students were involved in working with other students from different grades,"* declared Teacher I09 with considerable surprise.

Teachers' attitudes to teaching mathematics were clearly affected very positively by the use of manipulatives and peer tutoring together, and they described their increased enjoyment in both teaching maths and their relationships with their students. They showed during the interviews how much pleasure they now derived from their teaching since using both manipulatives and peer tutoring. *"I enjoy my maths classes much more than before,"* averred Teacher I07. *"They are so much more alive!"*

Teachers soon realised that the use of manipulatives and peer tutoring together affected students academically, as they developed a better understanding of mathematical concepts. Teacher I09 observed, *"With manipulatives and peer tutoring, my students were better able to understand maths concepts."* They reported that students understood maths more thoroughly and became more adept at both solving mathematical problems and explaining how they did so to others. Teacher I07 asserted, *"My students understand maths more deeply, and are able to explain what they know much better than before."* The students also achieved better exam results in mathematics. Teacher I08 boasted, *"Exam results showed that my students were better than others."* Students were using their free time at school to learn mathematics with each other, in a friendly competition to see who the best teacher was. Teacher I08 remarked, *"It was very interesting to see my students amicably competing with each other as to who taught best."*

6.2 Affective outcomes

6.2.1 Affective outcomes on students' attitudes towards mathematics

A 20-item questionnaire, to investigate changes in student attitudes to mathematics during the study, was also administered. All the information about the reliability and design of the questionnaire can be found in Section 4.1.5.2.

Table 6-2: The mean and standard deviation of the pre-test, post-test, and change (pre-post) upon the different groups involved in the study in the Attitude Towards Mathematics questionnaire

Group code	1	2	3	4
Group name	Control	Manipulative	Peer tutoring	Peer tutoring and manipulatives
Number of students	(n=192)	(n=151)	(n=143)	(n=141)
Number of classes	6	6	6	6
Pre-test	74.02 (9.73)	75.99 (9.74)	74.60 (8.15)	81.09 (9.02)
Post-test	70.98 (12.56)	75.93 (8.70)	74.58 (10.05)	81.09 (14.75)
Pre-post (change)	- 3.04 (11.74)	0.06 (10.11)	0.02 (10.79)	0.00 (14.53)

Table 6-2 reports the mean of the pre- and post-test Attitudes Towards Mathematics questionnaire, with Standard Deviation (*SD*) in each condition. Only data for students who completed both pre- and post-test are presented. Attrition was low (31 students) and therefore were no implications for the data in this respect.

Data indicated that, with the exception of the manipulatives and peer tutoring group, pre- to post-test changes were minimal. However, it should be noted that the control group showed a reduction in positive attitudes to mathematics, whereas experimental groups showed little change. In this instance it may be reasonable to conclude that the experimental condition may have negated a worsening in attitudes to mathematics.

Analysis indicated that the pre- and post-tests in each condition were normally distributed and therefore pre- post-test differences within condition were analysed using a two-way repeated measures ANOVA.

A two-way repeated measures ANOVA was conducted to assess whether the differences in pre- and post-test scores were significant in the conditions.

The results revealed that there were significant changes between the post-test mean scores and the pre-test mean scores within conditions: $F(3,605) = 2.888$, $p = .035$, partial $ή^2 = .014$. The interaction is displayed in Figure 8-2, showing a negative slope in the control group and horizontal line in the combined peer tutoring and manipulative group from the pre- to the post-test. Therefore, paired-sample *t*-tests were conducted to assess whether the differences from the pre- to post-test significant in all groups.

The paired-samples *t*-test showed that there was a significant decrease in the pre- to the post-test mean scores for the Attitudes Towards Mathematics questionnaire in the control group: (t (192) = 3.681, $p < 0.001$). The differences between pre- post-test mean scores in the manipulative group (t (146) = 0.66, p = 0.948) and the peer tutoring group (t (135) = 0.183, p = 0.855) were not significant. There were no differences between the pre- post-test mean scores in the combined manipulatives and peer tutoring group (t (136) = 0.00, p = 1.00).

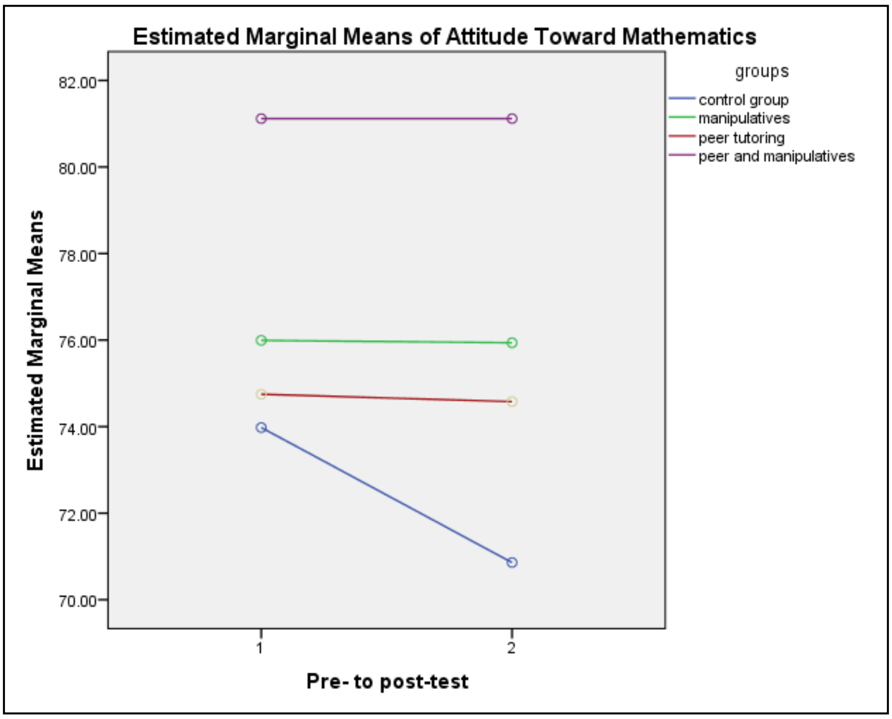

Figure 6-2: The changes in the mean scores from the pre- to the post-test in the Attitude Toward Mathematics questionnaire

The results of the two-way repeated measures ANOVA revealed that when the pre- and post-tests were combined there were significant differences between the groups: $F(3,605)= 26.909$, $p< .001$, partial $ή^2 = .118$.

Therefore, a three-way, between-subjects ANOVA with Bonferroni *post-hoc* test was conducted on the differences between the students' scores in the students' Attitude Towards Mathematics questionnaire to compare the differences between conditions. The three-way ANOVA test showed that there was a significant difference between the groups: $F(3,605)= 2.888$, $p= .035$, partial $ή^2 = .014$.

The results revealed that insignificant differences were found between the manipulatives group and the control group (p = .114), between the control group and the peer tutoring group (p = .164), between the control group and the combined peer tutoring and manipulatives group (p = .116), between the manipulatives only group and the peer tutoring only group (p = 1), between the manipulatives only group and the combined peer tutoring and manipulatives group (p = 1) or between the peer tutoring only group and the combined peer tutoring and manipulatives group.

6.2.1.1 Students' perspectives

Although a number of students reported a positive emotional reaction to using manipulatives in learning mathematics, there were others who reported negative feelings.

Some students reported that using manipulatives made the mathematics lessons more enjoyable and interesting. For example, one stated, *"I enjoy learning mathematics when we use manipulatives."* Using manipulatives also seemed to help students to be more confident in their learning, with one affirming, *"I feel more confident now, I love learning mathematics."*

On the other hand, there were students who stated that using manipulatives could be annoying and even boring, giving two reasons for that. One of them was poor social interaction in the lessons. As one explained, *"I want to work with other students, not with lifeless objects."*

The other reason they gave was the difficulty they encountered when using them. One student complained, *"I could not understand how manipulatives work ... it is really boring."*

Student from the peer tutoring group reported that with regard to their attitudes towards other students, they felt that peer tutoring resulted in their relationships with other students becoming friendlier and more relaxed. This encouraged them all to help each other more actively in the classroom. *"I love my classmates,"* said one. *"We learn with each other and we are helping each other."* There was also a feeling of positive academic competition between them. One admitted, *"After we finish the class I asked my partner, 'Did I tutor you better than you did me? Did you understand me well?' "* Another student reported, *"I love peer tutoring; it is like a friendly competition among each other."* Moreover, closer social relationships between the learning partners developed inside and outside school. A number of students stated, *"I like my learning partner more than before, and we enjoy spending more time together both inside and outside school."*

Secondly, the perceived effects of using peer tutoring on the students' attitudes towards the learning process itself that emerged from the interviews were interesting and salutary, since they said they found mathematics much easier than before. One said with surprise, *"Maths became much easier after I started learning with my learning partner."* The reason they gave was that they understood their partners better than they felt their teachers did. When asked for his reason for feeling that maths had become easier, one suggested, *"My partner explains maths in a simple way that makes me understand it better."* Students also said they enjoyed mathematics more after the introduction of peer tutoring, with statements such as, *"I love maths! It would be nice to have more classes."* Another went further, with, *"I would love to be a mathematician." "Maths is enjoyable with peer tutoring,"* said a third; and a fourth, *"I enjoy learning using peer tutoring; now I share this experience with my brothers, sisters, and friends inside and outside school."* Students evidently valued learning mathematics more than before, and recognised how important it was in life. One summarised the thoughts of many with, *"Maths is essential in life; it can help to develop our lives."* They also felt mathematics was good for developing their thinking.

Thirdly, the students observed a number of interesting developments in their own feelings, deriving from the effect of using peer tutoring and recognising, both directly and indirectly, that it positively increased their self-confidence. One asserted, *"Now I have more and more self-confidence."* Another said, *"I know that mathematics is not an easy subject, but it is now easy for me."* Increased self-confidence led to more self-reliance, and finding that they could individually do maths better than before. A third remarked, *"Although I love doing maths with my* *partner, I can also do maths on my own better than before."* Another put it thus: *"After using peer tutoring I find I can do many things on my own, relying on myself."*

The reason many of them gave was that their training and preparation had made them more confident in their mathematics. Observations such as, *"I'm very happy with myself since I learnt how to use peer tutoring,"* and *"Maths was difficult before, but now it isn't. Isn't that cool?"* were not uncommon. Students also noticed how their leadership skills developed while using peer tutoring, expressing this in comments such as, *"I am up for leading other people both inside and outside school, and in personal situations as well as at social events."*

The students using manipulatives and peer tutoring together described the resulting emotional changes they felt. Their opinions can be divided into three sections.

Firstly, they said they felt friendlier towards each other and liked each other more than before, with their relationships starting to be more relaxed. This, in turn, encouraged them to be more helpful and active inside the classroom. One described it thus: *"Our social relationship deepened and we now work more closely with each other."* In addition, positive competition between pairs was reported. *"It is such fun!"* said one. *"We vie with each other to see who is better."* Moreover, the relationship between learning partners developed inside and outside school. A number of students stated, *"I like my peer more than before, and we now enjoy spending more time together both inside and outside school."*

Secondly, with regard to the effects of using manipulatives and peer tutoring together on the students' personal feelings towards learning mathematics, like the students in the peer tutoring group they said they felt more positive. *"Maths is easier when manipulatives and peer tutoring are used together,"* said one, explaining that he understood his partner better: *"My partner explains things in an easy way."* Students also enjoyed mathematics much more. *"I love doing maths!"* and, *"I enjoy learning mathematics much more than before!"* summarises their feelings. They, too, recognised the importance of mathematics in everyday life and how significant it is in the development of our life and thinking. As one stated, *"Maths is one of life's essentials."*

Thirdly, the students attributed the positive increase in their self-confidence to the use of manipulatives and peer tutoring together, expressing this in ways such as, *"I have quiet confidence in myself."* It also increased their self-reliance and improved their ability to work independently, with one saying, *"I do maths on my own much better than before."* They also applied their mathematical ability to real life situations more successfully than previously, which gave them a satisfaction that showed both directly and indirectly throughout the interviews in such words as, *"Yes, I am so pleased with myself!"* They also described how their leadership skills had developed through the joint use of manipulatives and peer tutoring, with statements such as, *"I am now capable of leading, in personal situations and at social events."*

6.2.1.2 Teachers' perspectives

Teachers from the manipulatives group reported that using manipulatives can help students by enhancing their feelings of achievement, as they recognise their improved performance. They *"… felt that they were achieving more when using these manual tools than they had achieved without them."* noted Teacher I02.

Teachers from the peer tutoring group reported that students' emotional outlook had been affected by peer tutoring. They showed more respect for the teachers and for the subject. As has been noted above, they felt that students had more incentive to learn mathematics as they now enjoyed learning so much. Teacher I04 was pleased that his *"students showed more real relationship and respect for him than before, and it* *is obvious that they enjoy learning more than they used to."* Teacher I05 went one better: *"I have received many phone calls from a number of students' parents thanking me and telling me their sons were very happy that they enjoyed mathematics so much more than before."*

Teachers from the peer tutoring and manipulatives together group reported that students' psychology had been affected by using manipulatives and peer tutoring together. Students showed both more respect for their maths teachers, and increased enthusiasm for, and interest and enjoyment in, maths as a subject. Teacher I09 stated, *"My students show increasing respect for both me and maths, and they obviously enjoy learning."* Teacher I07 was happy to report that *"Even parents described how their sons were now enjoying mathematics."*

6.2.2 Peer's relationships

6.2.2.1 Attitude Towards Learning Partner questionnaire

A 20-item questionnaire, to investigate changes in student attitudes to their mathematics partner during the study, was also administered. Information about the reliability and design of the questionnaire can be found in Section 5.1.6.3.

Table 6-3: The mean and standard deviations of the pre-test, post-test, and change (pre to post) of the different groups involved in the study in the Attitude Towards Learning Partner questionnaire

Group code	1	2	3	4
Group name	Control	Manipulative	Peer tutoring	Peer tutoring and manipulatives
Number of students	(n=192)	(n=151)	(n=143)	(n=141)
Number of classes	6	6	6	6
Pre-test	75.02 (13.16)	74.35 (11.41)	69.38 (12.52)	75.27 (12.55)
Post-test	74.05 (14.19)	74.82 (14.66)	69.55 (12.13)	78.37 (17.10)
Pre-post (change)	0.97 (13.72)	0.47 (13.14)	0.17 (13.38)	3.1 (18.22)

Table 6-3 shows the mean and standard deviation (*SD)* of the pre- and post-test scores of the questionnaire on the students' attitudes towards their partners by conditions. Only data for students who completed both pre- and post-test are presented. Attrition was low (27 students) and therefore there were no implications for the data.

The mean of the students' scores in the questionnaire increased in all experimental groups in the post-test after the treatment. However, it decreased in the control group. The combined peer tutoring and manipulatives group had the greatest increase, of 3.1 (*SD* 18.22), as the mean of its pre-test score was 75.27 (*SD* 12.55) and the mean of its post-test score was 78.37 (*SD* 17.10). The control group showed a negative change from 75.02 (*SD* 13.16) to74.05 (*SD* 14.19), a mean change of 0.97 (*SD* 13.72).

Analysis indicated that the pre- and post-test in each condition were normally distributed in the Attitude Towards Mathematics Partner questionnaire and therefore pre- post-test differences within condition were analysed using the two-way repeated measures ANOVA.

A two-way repeated measures ANOVA was conducted to assess whether the differences in pre- post-test scores were significant in the conditions.

The results revealed that there were insignificant changes from pre- to post-test mean scores within conditions: $F(3,609)= 1.830$, $p= .141$, partial $ή^2 = .009$. The interaction is displayed in Figure 6-3, showing the positive slope from the pre- to post-test that both the combined peer tutoring and manipulatives group and manipulatives only group had and the negative slope from the pre- to post-test the control group had. Therefore, the paired-samples *t*-tests were conducted to assess whether the differences in pre- and post-test scores were significant in each group. The paired-samples *t*-tests indicated that there were no significant differences between the pre-and post-test mean scores in the Attitudes Towards Mathematics Partners' questionnaire; the control group (t (197) = 0.98, p = 0.328), the manipulative group (t (145) = - 0.58, p = 0.562), the peer tutoring group (t (135) = - 0.14, p = 0.893) and the combined manipulatives and peer tutoring group (t (136) = - 1.81, p = 0.072).

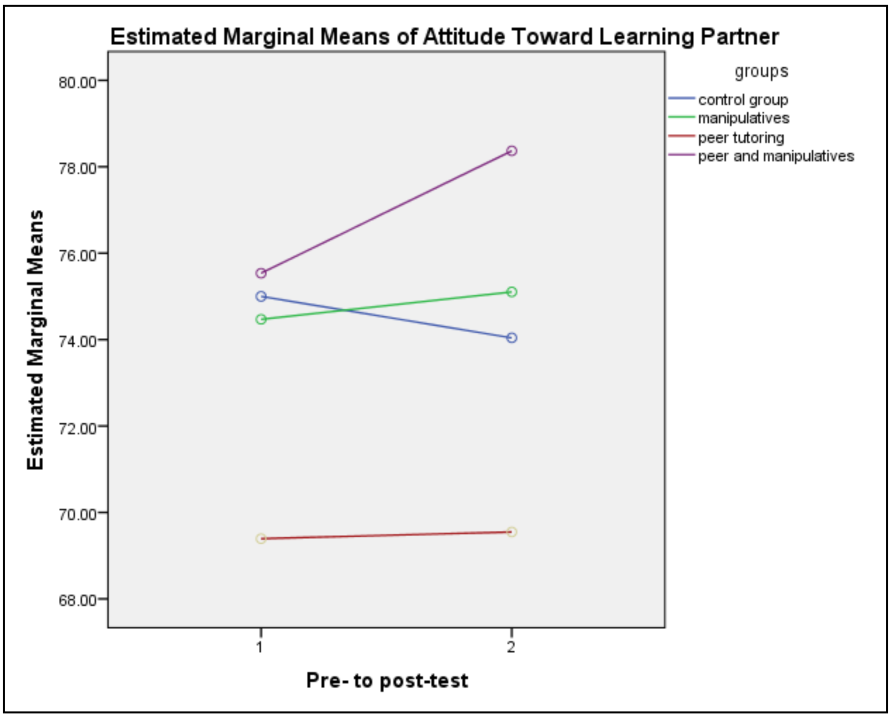

Figure 6-3: The changes in the mean scores from the pre- to the post-test in the Attitude Towards Learning Partner questionnaire

The results of the two-way repeated measures ANOVA revealed that when the pre- and post-tests were combined there were significant differences between the groups: F(3,609)= 10.417, p< .001, partial $\acute{\eta}^2$ = .049.

Therefore, a three-way between subjects ANOVA with Bonferroni *post-hoc* test was conducted on the differences between the students' scores in the students' Attitude

Towards Mathematics Partner questionnaire to compare the differences between conditions. The three-way ANOVA result revealed that there were insignificant differences between the groups: $F(3,609)= 1.830$, $p= 141$, partial $ή^2 = .009$.

The Bonferroni *post-hoc* results indicated that insignificant differences were found between the manipulatives group and the control group ($p = 1$), between the control group and the peer tutoring group ($p = 1$), between the control group and the peer combined tutoring and manipulatives group ($p = .123$), between the manipulatives only group and the peer tutoring only group ($p = 1$), between the manipulatives only group and the combined peer tutoring and manipulatives group ($p = 1$) or between the peer tutoring only group and the combined peer tutoring and manipulatives group ($p = .799$).

Table 6-4: The changes in the mean scores for the five keys factors emerging from the Attitude Towards Learning Partner questionnaire

Group code	1	2	3	4
Group name	Control	Manipulative	Peer tutoring	Peer tutoring and manipulatives
Number of students	(n=192)	(n=151)	(n=143)	(n=141)
Number of classes	6	6	6	6
Pre-Rotated Expected Working	16.23 (3.59)	17.11 (3.87)	15.22 (3.81)	16.28 (3.76)
Post-Rotated Expected Working	15.76 (3.74)	16.49 (4.60)	15.70 (3.71)	16.20 (4.44)
Change-Rotated Expected Working	0.47 (3.96)	0.62 (4.43)	-0.48 (4.41)	0.08 (4.91)
Pre-Factor Ability	19.22 (4.44)	18.81 (4.42)	17.92 (4.48)	19.63 (4.90)
Post-Factor Ability	19.17 (4.74)	19.06 (4.26)	17.84 (4.76)	20.55 (4.97)
Change-Factor Ability	0.05 (4.59)	-0.25 (4.49)	0.08 (4.80)	-0.92 (5.98)
Pre-Loading Physical Fitness	18.56 (4.24)	17.13 (3.82)	16.58 (3.90)	17.70 (4.39)
Post-Loading Physical Fitness	18.15 (4.68)	18.35 (5.84)	16.76 (3.62)	18.76 (5.31)
Change-Loading Physical Fitness	0.41 (4.34)	-1.22 (6.18)	-0.18 (4.40)	-1.06 (6.08)
Pre-Behaviour	7.14 (2.23)	7.53 (2.22)	6.99 (2.43)	7.46 (2.26)
Post-Behaviour	7.31 (2.16)	7.02 (2.26)	6.49 (2.15)	7.74 (2.36)
Change-Behaviour	-0.17 (2.27)	0.51 (2.65)	0.50 (2.88)	-0.28 (2.74)
Pre-Popularity	13.88 (3.05)	13.66 (3.25)	12.68 (2.80)	14.19 (3.11)
Post-Popularity	13.66 (3.39)	13.90 (3.67)	12.75 (3.36)	15.14 (3.68)
Change-Popularity	0.22 (3.33)	-0.24 (4.57)	-0.07 (4.14)	-0.95 (4.49)

6.2.2.2 People in Your Class (sociometric) questionnaire

The sociometric questionnaire measured the changes in the students' social interactions, revealing the number of friends the students had in five contexts before and after the intervention. Further information about this questionnaire can be found in Section 5.1.6.4.

Table 6-5: The mean and standard deviation of the pre-test, post-test, and change (pre to post) upon the different groups involved in the study in the Sociometric questionnaire

Group code	1	2	3	4
Group name	Control	Manipulative	Peer tutoring	Peer tutoring and manipulatives
Number of students	(n=192)	(n=148)	(n=135)	(n=137)
Number of classes	6	6	6	6
Pre-test	62.19 (48.01)	92.71 (96.59)	133.82 (75.82)	189.64 (66.83)
Post-test	66.40 (49.47)	93.66 (106.27)	212.89 (106.65)	357.71 (87.41)
Pre-post (change)	4.21 (29.22)	0.95 (36.39)	79.07 (57.22)	186.07 (71.64)

Table 6-5 shows the mean and standard deviation (*SD)* of the pre-test, post-test and changes in the sociometric instrument scores. Only data for students who completed both pre- and post-tests were presented. Attrition was low (26 students) and therefore there were no implications for the data.

There were changes in pre- to post-test scores in all conditions. However, these were lower in the control group 4.21 (*SD* 29.22) and the manipulatives group 0.95 (*SD* 36.39) than in either the combined peer tutoring and manipulatives group 168.07 (*SD* 71.64) or the peer tutoring group 79.07 (*SD* 57.22).

Analysis indicated that the pre- and post-tests in each condition were normally distributed in the sociometric questionnaire and therefore pre- to post-test differences within conditions were analysed using a two-way repeated measures ANOVA.

A two-way repeated measures ANOVA was conducted to assess whether the differences between pre- and post-test scores were significant in the conditions.

The results revealed that the post-test mean scores were significantly higher than the pre-test mean scores within conditions: $F(3,610) = 376.629$, $p<.001$, partial $ή^2 = .649$. The interaction is displayed in Figure 6-4, showing a positive slope from the pre- to post-test of both the combined peer tutoring and manipulatives group and peer tutoring group. Therefore, paired-samples *t*-tests were conducted to assess whether the differences between pre- and post-test scores were significant in all groups.

The paired-samples *t*-test showed that there were significant differences between pre- and post-test results in the mean score in the sociometric questionnaire; the control group ($t(169) = -2.07$, $p = 0.040$), the peer tutoring group ($t(134) = -16.07$, $p < 0.001$) and the combined peer tutoring and manipulatives group ($t(137) = -27.46$, $p < 0.001$). However, the differences between the pre- and post-test mean scores in the manipulatives group were not significant ($t(147) = -0.26$, $p = 0.797$).

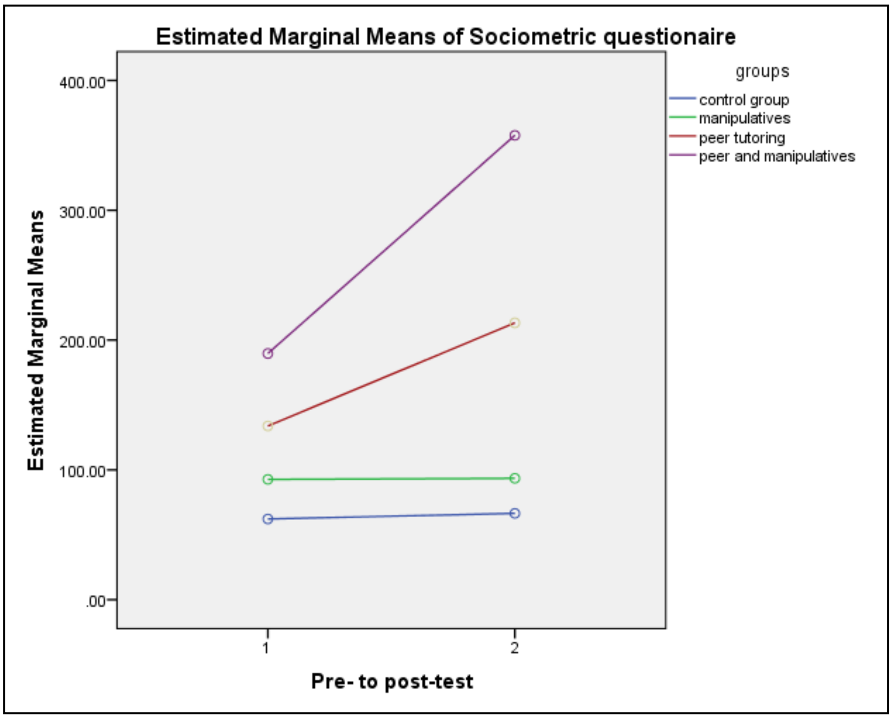

Figure 6-4: The changes in the mean scores from the pre- to the post-test in the Sociometric questionnaire

The results of the two-way repeated measures ANOVA revealed that when the pre- and post-tests were combined, there were significant differences between the groups: $F(3,610)= 230.342$, $p< .001$, partial $ή^2 = .531$.

Therefore, a three-way, between-subjects ANOVA with Bonferroni *post-hoc* test was conducted on the differences between the students' scores in the students' sociometric questionnaire to compare the differences between conditions. The three-way between subjects ANOVA results revealed that there were significant differences between the groups: $F(3,610)= 376.629$, $p< .001$, partial $ή^2 = .649$.

Bonferroni *post-hoc* results revealed that the differences between the students' scores in the sociometric questionnaire were significantly higher in the peer tutoring group than in the control group ($p< .001$). The differences between these mean scores in the combined manipulatives and peer tutoring group were significantly higher than in the control group ($p< .001$). However, the differences were not significant between the control group and the manipulatives group in the sociometric questionnaire ($p= 1$).

The differences between the students' mean scores in the sociometric questionnaire in the peer tutoring group were significantly higher than the manipulatives group ($p< .001$) while the differences between these scores in the combined manipulatives and peer tutoring group were significantly higher than those in the manipulatives only group ($p< .001$). The differences between the students' mean scores in the sociometric questionnaire in the combined peer tutoring and manipulatives group were significantly higher than the peer tutoring only group ($p< .001$).

6.2.2.3 Students' perspectives

Manipulatives were reported by the students in the manipulatives group to be effective in promoting their learning. Students like to learn in a social environment, in which they can develop unstructured cooperative learning opportunities. One student said, "*I love learning with other students using manipulatives to teach each other maths."* Another said, *"When another student asks me to teach him maths, I think of manipulatives to help me teach him."* He added, *"Since my teacher started using manipulatives, I love communicating with other students to teach them maths."* However, not all students used manipulatives in a social context and some liked to use them to learn independently. A student when asked about using manipulatives in learning mathematics replied, *"I love using them; they are helping me to learn independently without asking others."* When he was asked if he would like to teach other students, he asked, *"Why I should give my work to other students?"*

Students in the peer tutoring only group reported a number of positive effects on their social relationship patterns as a result of using peer tutoring in learning mathematics, one being that they noticed they started to have more friends. For example, *"Every day after starting peer tutoring, I found I had more friends, and I started to enjoy making friends,"* said one. Making new friends occurred inside and outside both the classroom setting and the school. The reason students gave for this effect on their improved social relationships patterns was the development they recognised in their interpersonal skills. As one declared, *"I feel more confident making friends now; I know how to make them more effectively than before,"* while another reported, *"Now I can speak better in conversations."*

There were also students who stated that their social relationships in general started to grow stronger than before, particularly inside the school. They stated, for example, that they started to spend more time together both during and after school hours, and were enjoying their social relationships more than they had previously. One observed with surprise, *"I enjoy my friends more than before, we love spending more time together and now we meet more inside and outside school."* Moreover, the students seem to be more satisfied with the social climate in the classroom. One put it this way: *"Our class is friendlier and our relationships in the class are improving daily."* It became apparent that they had established a social group in the school for peer tutoring which aimed to use peer tutoring to reach academic and social targets. *"The members of the social group are meeting for social and academic purposes,"* said one. *"We are helping each other academically and make more friends."*

One of the most interesting ideas that students expressed was the change in some of their perceptions when dealing with other students. For example, *"In the past when other students asked me about something in maths I told them they were cheating,"* said one, *"but now when someone asks me about something, in maths or any other subject, I show him how to work it out for himself. In other words, we cooperate."* Another emphasised, *"We are now helping each other to understand maths, though we don't share answers as such."*

Even the relationship between teachers and students became more social and active. *"After we engaged in peer tutoring, we started to socialise more with our teachers,"* noted one.

Students in the peer tutoring and manipulatives together group highlighted a number of interesting social effects resulting from the use of manipulatives and peer tutoring together in learning mathematics, which were very similar to those put forward by the students from the group using peer tutoring alone. Therefore there will inevitably be some repetition of themes in this section.

The former described a number of effects on their social relationships that had resulted from the use of manipulatives and peer tutoring together. They noticed that they started to have more friends, with one observing, *"My friends increase in number every day now. The use of manipulatives and peer tutoring together really helped this to happen."* Another said, *"I am making more friends since we started* *using both manipulatives and peer tutoring."* They recognised that this positive effect was felt inside and outside both the classroom and the school and said they felt their social relationship skills had improved as a result of using manipulatives and peer tutoring together.

A number of students who were interviewed from this group also noticed that their social relationships patterns were growing stronger than before; they were spending more time together inside and outside the school and enjoying their social relationships more. One said, *"We were friends at school, but we are now like brothers."* The social environment in the classrooms and schools developed positively, and the students showed they were happy with that with such comments as, *"I am so happy with the social environment that has been established."*

They also felt that the use of manipulatives in the social context of peer tutoring was really effective. *"When I teach my learning partner a mathematical concept, it is much easier to use manipulatives to explain it,"* and, *"We use manipulatives to make our learning a more sociable activity inside and outside the classroom, even in our homes. It is a most enjoyable experience,"* were representative comments.

These students echoed what the students from the peer tutoring group had said about their change of perception in their dealings with other students during mathematics lessons. They said they now cooperated and shared their problem-solving much more. They also repeated the idea that the relationships between them and the teachers had become more social and fruitful.

6.2.2.4 Teachers' perspectives

The use of manipulatives as reported by the teachers in the manipulatives group affected the relationship between teachers and students in positive way, evidenced in their satisfaction with their students' performance. *"My students perform much better in maths than before,"* observed Teacher I03. *"I really like that."* The other change teachers felt in their relationship with students was a recognition of the students' more positive attitude towards them, both inside and outside the classroom. Teacher I03 noted with pleasure, *"Students now show more respect for me and a greater love of the subject than before."* Teachers were also happy to find that their students were more involved with the subject in the classroom, with Teacher I02 speaking for many when he commented, *"Students are more engaged in the classroom activity. They are happy with me and my teaching."*

Using manipulatives helped students to be more actively involved in their learning by sharing their work with each other in lessons, which helped them to benefit from each other's knowledge and experiences. Teacher I01 recognised that *"The use of manipulatives helps me a great deal in establishing an active learning environment. I advise all teachers to use manipulatives…"*

Teachers who used peer tutoring in their teaching discussed the way in which it had affected their relationships with the school's senior management, their colleagues and their students.

Peer tutoring had affected their relationships with the senior management very positively. Teacher I04 reported proudly, *"The headteacher was not only happy with me and what I was doing, but he also asked me to share my experiences with other teachers."* Teacher I06 was also clearly delighted with the reaction to his work: *"This year I was the winner of the prize for the best teacher in the school. The headteacher constantly thanked me for using peer tutoring - he was very happy with the resulting effects of it that he could feel in the school."*

Teachers also stated that the use of peer tutoring positively affected their relationship with other teachers, who were now asking if they would share this experience with them. *"Many teachers came to me and asked me to share the techniques of peer tutoring with them,"* said Teacher I04 with satisfaction, while Teacher I06 stated with pride, *"It gives me great pleasure to be able to help my colleagues by sharing the techniques of peer tutoring with them."*

Teachers were also very happy with the changes they felt in their relationships with students. *"They are not just my students now; they have become my friends too. We enjoy sharing time with each other in school,"* said Teacher I06, representing the views of them all.

Teachers made a number of interesting observations about the effect on their students' social lives, behaviour and relationships following the use of peer tutoring in mathematics lessons. They noticed that relationships between students had developed and improved since peer tutoring was integrated into learning. Students, they noted, were making more friends. Teacher I05 stated, *"I have seen many students who had few friends, or even none, now walking with four or five friends at school, and when I asked them about this development they replied, 'We are much more aware of how to make friends now'."* As reported earlier, relationships between students grew stronger, which the teachers also noticed. Said Teacher I06, *"It is easy to see students' relationships growing deeper as they enjoy spending more time with each other."* They recounted a number of personal stories they were told by their students, describing their increased pleasure at the way in which peer tutoring had affected their relationships. For instance, Teacher I04 reported that, *"My students have told me a number of stories about making new friends both in and out of school, how their relationships have developed and how pleased they are about all this."* Furthermore, teachers noted with pleasure the way students were working more cooperatively with each other. *"Students were helping each other to do their homework by explaining things,"* remarked Teacher I06.

Teachers who were using manipulatives and peer tutoring together all affirmed that their relationships with the senior management, their other colleagues and their students had all been influenced positively by it.

All described in the interviews how pleased the head teacher was with them, with Teacher I07 summarising the views of them all when he said, *"The headteacher was pleased with me and asked me to train other teachers in the use of manipulatives and peer tutoring."*

They maintained that their relationships with other teachers were affected positively, since their colleagues, too, asked them to share their experiences with them. *"My colleagues asked me to share the experience of using both manipulatives and peer tutoring with them",* said Teacher I07. *"They were impressed with the results they had seen in the school."* Teacher I09 agreed with this, claiming, *"Yes, my relationship with other teachers is getting stronger, friendlier and more useful, as we discuss our teaching experiences more than before."*

Teachers reported that the relationships with their students were similarly positively affected. They found that students were asking more questions both in and out of class. *"I felt that all barriers between my students and me had disappeared,"* reported Teacher I09.

Teachers observed a number of effects on their students' social behaviour following the use of manipulatives and peer tutoring together in their maths lessons. They reported that personal relationships between students had developed very positively as a result. In the words of Teacher I08, *"Students were making more friends. I have seen many normally unsociable students making friends and becoming increasingly sociable".* He was supported by Teachers I09 and I07, who confirmed respectively that, *"Students' relationships were getting stronger,"* and, *"Students' relationships grew deeper and stronger, and they showed their pleasure in this in different ways."*

Teachers also reported a number of personal stories they heard from their students of their satisfaction as a result of this. As Teacher I09 remarked, *"My students described their experiences of making new and deeper relationships than before; yet another benefit they attributed to the use of manipulatives and peer tutoring."* Students also became more cooperative. *"It is amazing seeing pupils helping each other to do maths,"* observed Teacher I07, with some surprise.

6.3 Regression analysis of the data

In order to establish the significance of the gains in the five key sociometric measures (percentage of the members of their class children liked to 'work with in mathematics lessons', 'work with in other lessons', 'share the break time with', 'share the time outside school' and 'go to the Masjed with') post-scores in predicting the pattern of attainment in the mathematics scores post-tests, a regression analysis was done. This regression analysis was applied to each group of the control group, the manipulative group, the peer tutoring group, and combined the manipulatives and peer tutoring group. In addition, regression analysis was used to establish the significance of data and other measures of the students' pre-scores Attitudes Towards Learning Partners instrument in predicting the pattern of attainment in the post-tests.

6.3.1 Regression result for group one (the control group)

An insignificant model emerged of the post-test sociometric questionnaire variables. None of the variables 'Like to work with at maths lesson', 'Like to work with in other lessons', 'Like to share the break time with', 'Like to share the time outside school' and 'Like to go to the Masjed with' were significant predictors to the post-test results of the students in the control group.

An insignificant model emerged of the factors of the pre-test Attitudes Towards Mathematics Partners questionnaire variables. None of the variables 'Rotated expected working', 'Factor ability', 'Loading physical fitness', 'Behaviour' and

‘Popularity’ were significant predictors to the post-test results of the students in control group.

Table 6-6 below gives information about the regression coefficients for the predictor variables entered into the model.

Table 6-6: The unstandardised and standardised regression coefficients for the variables entered into the model

Predictor Variable	R square	Adjusted R square	Beta	*p*	F
Liked to work with at maths lesson	.002	-.003	.043	.544	(F (1, 195) = 0.369, p = 0.544)
Liked to work with in other lessons	.016	.011	.128	.072	(F (1, 195) = 3.265, p = 0.072)
Liked to share the break time with	.001	-.004	.031	.670	(F (1, 195) = 0.183, p = 0.670)
Liked to share the time outside school	.008	.003	.087	.223	(F (1, 195) = 1.496, p = 0.223)
Liked to go to the Masjed with	.003	-.003	.051	.479	(F (1, 195) = 0.504, p = 0.479)
Rotated Expected Working	.004	-.001	.061	.391	(F (1, 195) = 0.738, p = 0.391)
Factor Ability	.019	.014	.137	.054	(F (1, 195) = 3.749, p = 0.054)
Loading Physical Fitness	.019	.013	.136	.057	(F (1, 195) = 3.677, p = 0.057)
Behaviour	.006	.001	.080	.261	(F (1, 195) = 1.272, p = 0.261)
Popularity	.011	.006	.104	.146	(F (1, 195) = 2.128, p = 0.146)

6.3.2 Regression result for group two (the manipulatives group)

An insignificant model emerged of the post-test sociometric questionnaire variables. None of the variables ‘Like to work with at maths lesson’, ‘Like to work with in other lessons’, ‘Like to share the break time with’, ‘Like to share the time outside school’ and ‘Like to go to the Masjed with’ were significant predictors of the post-test results of the students in the manipulatives group.

An insignificant model emerged the factors of the pre-test Attitude Towards Mathematics Partner questionnaire variables. None of the variables 'Rotated expected working', 'Factor ability', 'Loading physical fitness', 'Behaviour' and 'Popularity' were significant predictors of the post-test results of the students in the manipulatives group.

Table 6-7 gives information about regression coefficients for the predictor variables entered into the model.

Table 6-7: The unstandardised and standardised regression coefficients for the variables entered into the model

Predictor Variable	R square	Adjusted R square	Beta	*p*	F
Liked to work with at maths lesson	.001	-.006	.029	.730	(F (1, 145) = 0.120, p = 0.730)
Liked to work with in other lessons	.005	-.002	.069	.410	(F (1, 145) = 0.684, p = 0.410)
Liked to share the break time with	.014	.007	.118	.153	(F (1, 145) = 2.064, p = 0.153)
Liked to share the time outside school	.006	-.001	.076	.360	(F (1, 145) = 0.845, p = 0.360)
Liked to go to the Masjed with	.003	-.004	.051	.542	(F (1, 145) = 0.374, p = 0.542)
Rotated Expected Working	.015	.009	-.124	.132	(F (1, 146) = 2.289, p = 0.132)
Factor Ability	.004	-.003	-.060	.471	(F (1, 145) = 0.523, p = 0.471)
Loading Physical Fitness	.006	-.001	.078	.344	(F (1, 146) = 0.900, p = 0.344)
Behaviour	.004	-.002	-.067	.419	(F (1, 146) = 0.658, p = 0.419)
Popularity	.013	.006	.115	.164	(F (1, 146) = 1.953, p = 0.164)

6.3.3 Regression result for group three (the peer tutoring group)

The post-test sociometric questionnaire variables that significantly correlated with criterion-variable, post-test scores of the attainment test were entered as predictors into a multiple regression using standard method.

A significant model emerged from the variable 'Liked to work with at maths lesson': (*F* (1, 133) = 4.314, $p = 0.040$). The model explains 2.4% of the variance in the post-test scores of the attainment test (Adjusted $R^2 = .024$). Table 8-7 gives information about regression coefficients for the predictor variables entered into the model. This variable was significant predictor in this model, with a positive relationship to the post-test scores of the attainment test.

Another significant model emerged of the variable 'Liked to work with in other lessons': (*F* (1, 133) = 5.264, $p = 0.023$). The model explains 3.1% of the variance in the post-test scores of the attainment test (Adjusted $R^2 = .031$). Table (8-7) gives information about regression coefficients for the predictor variables entered into the model. This variable was significant predictor in this model, with a positive relationship to the post-test scores of the attainment test.

A significant model emerged from the variable 'Like to share the break time with': (*F* (1, 133) = 10.309, $p = 0.002$). The model explains 6.5% of the variance in the post-test scores of the attainment test (Adjusted $R^2 = .065$). Table 8-7 gives information about regression coefficients for the predictor variables entered into the model. This variable was significant predictor in this model, with a positive relationship to the post-test scores of the attainment test.

A significant model emerged from the variable 'Like to share the time outside the school with': (*F* (1, 133) = 8.911, $p = 0.003$). The model explains 5.6% of the variance in the post-test scores of the attainment test (Adjusted $R^2 = .056$). Table (8-7) gives information about regression coefficients for the predictor variables entered into the model. This variable was significant predictor in this model, with a positive relationship to the post-test scores of the attainment test.

A significant model emerged from the variable 'Liked to go to the Masjed with': (*F* (1, 133) = 9.485, $p = 0.003$). The model explains 6% of the variance in the post-test scores of the attainment test (Adjusted $R^2 = .060$). Table 8-8 gives information about regression coefficients for the predictor variables entered into the model. This variable was significant predictor in this model, with a positive relationship to the post-test scores of the attainment test.

Insignificant models emerged of the factors of the pre-test Attitudes Towards Mathematics Partners questionnaire variables. None of the variables 'Rotated expected working', 'Factor ability', 'Loading physical fitness', 'Behaviour' and 'Popularity' were significant predictors to the post-test attainment results.

Table 6-8: The unstandardised and standardised regression coefficients for the variables entered into the model

Predictor Variable	R square	Adjusted R square	Beta	*p*	F
Liked to 'work with at maths lesson'	.031	.024	.177	.040	(F (1, 133) = 4.314, p = 0.040)
Liked to 'work with in other lessons'	.038	.031	.195	.023	(F (1, 133) = 5.264, p = 0.023)
Liked to 'share the break time with'	.072	.065	.268	.002	(F (1, 133) = 10.309, p = 0.002)
Liked to 'share the time outside school'	.063	.056	.251	.003	(F (1, 133) = 8.911, p = 0.003)
Liked to 'go to the Masjed with'	.067	.060	.258	.003	(F (1, 133) = 9.485, p = 0.003)
Rotated Expected Working	.001	-.006	.036	.682	(F (1, 133) = 0.168, p = 0.682)
Factor Ability	.000	-.007	-.005	.952	(F (1, 133) = 0.004, p = 0.952)
Loading Physical Fitness	.001	-.006	.033	.704	(F (1, 133) = 0.145, p = 0.704)
Behaviour	.028	.021	-.168	.052	(F (1, 133) = 3.846, p = 0.052)
Popularity	.003	-.005	-.054	.532	(F (1, 133) = 0.392, p = 0.532)

6.3.4 Regression result for group four (the combined manipulatives and peer tutoring group)

Insignificant models emerged of the post-test sociometric questionnaire variables. None of the variables ‘Like to work with at maths lesson’, ‘Like to work with in other lessons’, ‘Like to share the break time with’, ‘Like to share the time outside school’ and ‘Like to go to the Masjed with’ were significant predictors to the post-test results of the students in the combined peer tutoring and manipulatives group.

An insignificant model emerged of the factors of the pre-test Attitudes Towards Mathematics Partners questionnaire variables. None of the variables ‘Rotated expected working’, ‘Factor ability’, ‘Loading physical fitness’, ‘Behaviour’ and ‘Popularity’ were significant predictors of the post-test results of the students in the manipulatives and peer tutoring group.

Table 6-9 gives information about regression coefficients for the predictor variables entered into the model.

Table 6-9: The unstandardised and standardised regression coefficients for the variables entered into the model

Predictor Variable	R square	Adjusted R square	Beta	*p*	F
Liked to 'work with at maths lesson'	.007	.000	.086	.317	(F (1, 135) = 1.010, p = 0.317)
Liked to 'work with in other lessons'	.007	.000	.086	.317	(F (1, 135) = 1.010, p = 0.317)
Liked to 'share the break time with'	.008	.000	.087	.311	(F (1, 135) = 1.032, p = 0.311)
Liked to 'share the time outside school'	.007	.000	.085	.326	(F (1, 135) = 0.972, p = 0.326)
Liked to 'go to the Masjed with'	.007	.000	.084	.331	(F (1, 135) = 0.952, p = 0.331)
Rotated Expected Working	.000	-.007	-.009	.917	(F (1, 136) = 0.011, p = 0.917)
Factor Ability	.000	-.007	-.011	.900	(F (1, 136) = 0.016, p = 0.900)
Loading Physical Fitness	.000	-.007	-.017	.840	(F (1, 136) = 0.041, p = 0.840)
Behaviour	.011	.004	.104	.224	(F (1, 136) = 1.492, p = 0.224)
Popularity	.005	-.002	.074	.389	(F (1, 136) = 0.748, p = 0.389)

6.4 Fidelity check

The researcher developed training programmes for the teachers, made observational visits and held weekly meetings with the teachers which allowed them the opportunity to express any difficulties they were encountering in applying the interventions. These meetings also offered the opportunity for the researcher to 'troubleshoot' any issues arising in the interventions. Further, the teachers were advised they could feel free to contact the researcher at any time if they had any enquiry about the application of the interventions. Some teachers who were felt by the researcher to be having difficulties in the application of the interventions were advised to visit the classrooms of teachers who were confident in their application in order to benefit from their approaches. More detailed information on the procedure of the fidelity check can be found in Chapter 3.

Having followed the procedure of the fidelity check, the researcher was satisfied with the teachers' application of the interventions and with the students' engagement in and interaction with them.

7 CHAPTER SEVEN: DISCUSSION

This study is an RCT examination to establish the effects of using peer tutoring and manipulatives, both separately and together, on elementary stage, fourth grade students in the Kingdom of Saudi Arabia in AlAhsa city. One control group and three experimental groups, of two classes each in the pilot study and six classes each in the main study, participated in the study. Teachers assigned to experimental groups were trained in the interventions they were to offer their students. All students did pre-tests before the interventions and post-tests after them, in all combinations of the study instruments.

Four elements were examined in all the groups in this study: the students' attainments, their attitudes towards mathematics, their attitudes towards their learning partners, and their social relationships. In addition, the relationship between the students' social interactions and their attainments was examined.

The results of this study should both offer effective strategies to help students improve their learning in various ways, including their attainments and social relationships It will also present suggestions that will lead to positive developments in students' and teachers' performances, and therefore the overall standards of education in Saudi Arabia.

This RCT used complex methods in order to fulfil the aims of the study. An Attainment Test, an Attitude Towards Mathematics questionnaire, an Attitudes Towards Learning Partners questionnaire and a Social Relationships questionnaire were used in the quantitative part of the study. Interviews with teachers and students involved in the experimental groups were used in the qualitative part. Observations were made in order to track the performance of the experimental groups and the control group in both the pilot study and the main study.

In this chapter, the results from both the quantitative and qualitative parts of the study will form the basis for the discussion, which will focus on the research hypotheses initially laid out in Chapter One and repeated below.

The original hypotheses developed for testing as part of this study were as follows:

H01: In the Attainment Test, there would be no significant change between the pre-test mean scores and the post-test mean scores for each condition.

H02: In the Attainment Test, there would be no significant differences between the experimental groups' mean scores and the control group's mean score.

H03: In the Attitudes Towards Mathematics questionnaire there would be no significant change in the pre-test mean scores and the post-test mean scores for each condition.

H04: In the Attitudes Towards Mathematics questionnaire there would be no significant differences between the experimental groups' mean scores *vs*. the control group's mean score.

H05: In the Attitudes Towards Learning Partner questionnaire there would be no significant change in the pre-test mean scores and post-test mean scores for each condition.

H06: In the experimental groups' Attitudes Towards Learning Partner questionnaire there would be no be significant differences between the experimental groups' mean scores and those of the control group.

H07: In the People in Your Class questionnaire there would be no significant change in the pre-test mean scores and students' post-test mean scores for each condition.

H08: In the People in Your Class questionnaire there would be no significant differences between the experimental groups' mean scores and the control group's mean score.

H09: A significant relationship would not be established between the five key sociometric measures (percentage of the members of their class whom they liked to 'work with at maths lesson', 'work with in other lessons', 'share the break time with', 'share the time outside school with' and 'go to the Masjed (the Muslim place of worship) with') in predicting the pattern of attainment in the post-test mathematics scores.

H10: A sufficiently significant relationship would not be established between the five key factors (Rotated expected working, Factor ability, Loading physical fitness, Behaviour, and Popularity) that emerged from the Attitude Towards the Learning Partner questionnaire, to predict the pattern of attainment in the post-test mathematics scores.

This discussion chapter will be structured as follows. After the introduction, the factors essential to an effective learning strategy will be discussed in Section 7.1. These factors consist of good lesson planning; the maximisation of the student's role; cognitive tools; and the use of peer tutoring and manipulatives together in learning mathematics. Following this, in Section 7.2, there will be a discussion of whether social skills affect academic outcomes and if so, in what way. Next, in Section 7.3, there will be a general discussion, followed in Section 7.4 by a discussion on the specifications and challenges of conducting RCTS of conducting RCTs in Saudi Arabia. Finally, in Section 7.5, the limitations of the study will be discussed.

7.1 Factors essential to an effective learning strategy

There are four essential factors in any effective learning strategy: the use of a social learning method; the maximisation of students' roles; good lesson planning, and; the use of cognitive tools. Peer tutoring is an example of a social learning method and manipulatives are an example of cognitive tools. Peer tutoring and manipulatives are both components in the factors of the maximisation of students' roles and good lesson planning. Learning mediation can be enhanced by the use of both peer tutoring and manipulatives. Hence, an outcome of the use of both peer tutoring and manipulatives is an increase in students' communication, which in turn is reflected in cognitive and affective factors. The cognitive factors are better understanding and increased attainment, which are related to metacognitive understanding. Increased self-confidence and improved social relationships are the affective factors related to an affective increase. Thus, all four of these factors are a result of increased communication, which is, in turn, an outcome of the use of peer tutoring and manipulatives. Further, the cognitive and affective factors have an impact on each other in that better understanding and increased self-confidence interact to result in enhanced self-regulation. The interaction of the outcomes of using manipulatives and peer tutoring will enhance the quality of their use, which again will enhance the outcomes and so forth.

The following sub-sections discuss the four main elements and their relationship to this study's results and to the literature.

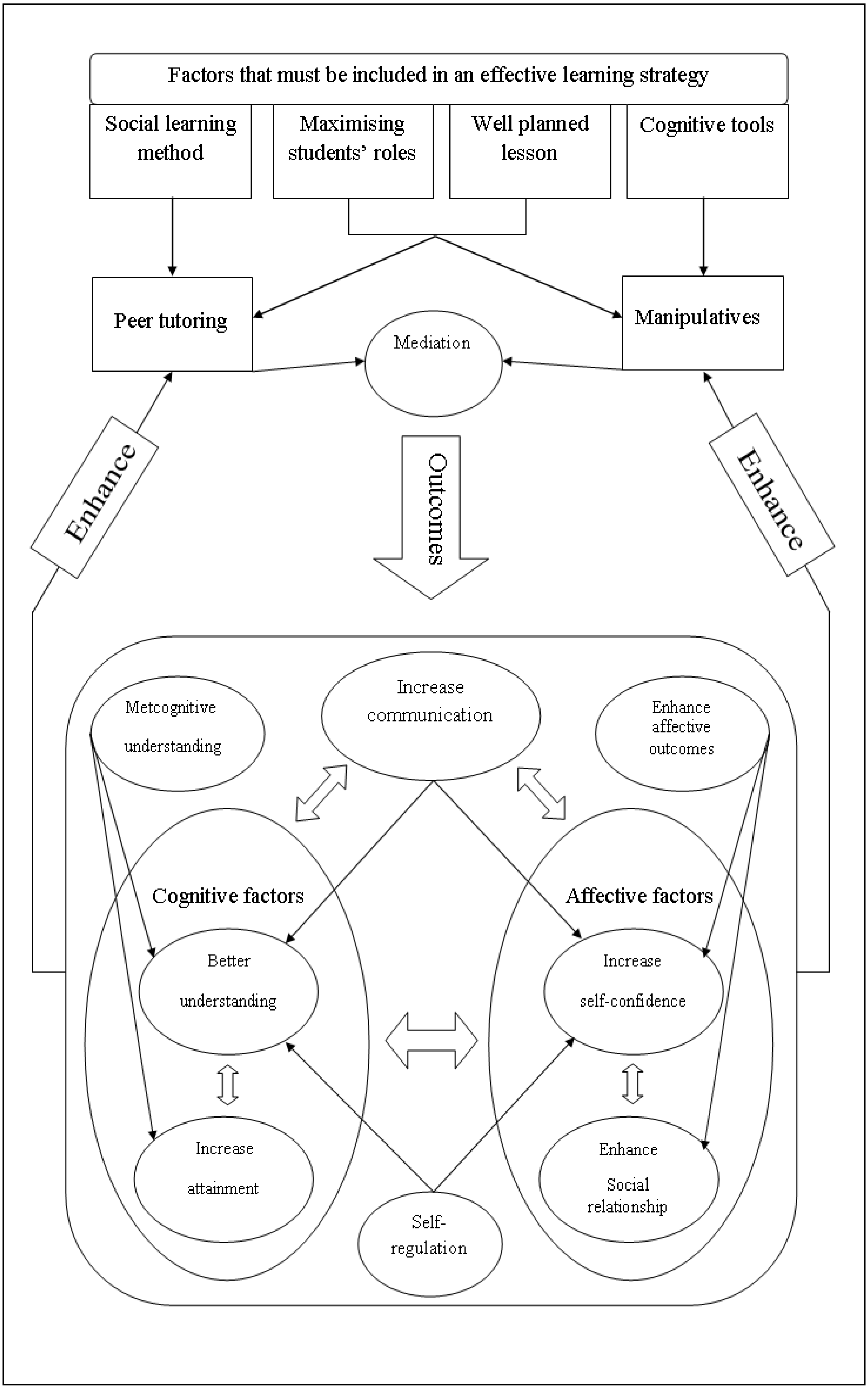

Figure 7-1: Factors and outcomes of teaching strategy using a combination of peer tutoring and manipulatives

7.1.1 Good lesson planning

There is a general consensus amongst educational professionals that planning is a crucial part of teaching (Clark & Yinger, 1987). The focus of such planning should be a clear lesson structure and the specification of clear goals (Jones & Smith, 1997). However, there is considerable evidence to suggest that that planning is a complex and challenging task in which teachers in general and mathematics teachers in particular, are involved in the transformation and interpretation of a wide range of knowledge (John, 1993, 1994; Martin, 1994). Consistent with this, the results of this present study suggest that teachers in Saudi Arabia are in need of a framework that will help them to plan their lessons in such a way as to maximise their effectiveness. This could be inferred from the students in the control group showing a lower mean score in the Attainment Test and the Sociometric questionnaire than did those in the experimental groups. In addition, the attitude of the students in the control group towards mathematics also became more negative. However, that of the students in the experimental groups remained the same, as was demonstrated by the results of the Attitudes Towards Mathematics questionnaire.

Although beginning with objectives may help teachers to focus on what students may learn during a lesson, there is a risk that it could result in inflexible plans that stress those parts of the mathematics curriculum which are easiest to measure, while tending to neglect the more creative and unstructured elements of mathematical thinking (Jones & Smith, 1997).

There are a number of reasons which make lesson planning one of the most important components of the teacher's responsibility. For example, good planning establishes clear aims and ensures the inclusion of essential content, as well as permitting the teacher to schedule work in a logical sequence and in practical time units (Reys et al, 1995). Reys et al (1995) further assert that good lesson planning assists in holding students' attention, helps to avoid unnecessary repetition and instils a feeling of confidence in the teacher.

The results of this current study indicate that well-structured activities are important in any successful peer tutoring. Therefore, when planning their lessons, teachers should ensure that the necessary materials for the lesson are prepared. Given the importance of involving materials such as manipulatives in increasing the advantages of peer tutoring in mathematics, it is suggested that teachers should provide these manipulatives when they use peer tutoring.

With regard to lesson planning, the interviews in this present study, in both formal and informal conversations, the teachers in the combined peer tutoring and manipulatives group expressed they would appreciate help to plan lessons effectively to involve social learning activities and cognitive tools in their teaching. This study represents a well-structured and evaluated strategy using peer tutoring as a social learning strategy and manipulatives as cognitive tools. The comprehensive results of this study lead to the recommendation that the use of this well-structured strategy can help teachers to plan their lessons effectively and enhance their students academically, socially and emotionally.

7.1.2 Maximisation of students' role

Learners are the centre of the learning process, as cognitive constructivists hold. They must be actively involved in the learning process; rather than being recipients of knowledge from others, they constructing and extend their body of knowledge themselves (Poplin, 1988). One of the advantages that teachers can gain from involving their students in the learning process, is that they can be sure that their students have understood correctly. This is to say, both teachers and students will benefit from the creation of an active learning environment and student involvement activities such as group discussion. At the same time, students can give their teachers' feedback to reach levels of meaningful understanding, while teachers can verify students' understanding.

In terms of the student's role, social constructivists also believe that students are active and that every student has a significant and effective role to play in the learning process, acting as student and teacher at the same time (Philips & Soltis, 2004). The students can have a positive interaction with other learners in the social learning setting created and developed by the teachers, using cognitive tools such as manipulatives (Gredler, 1997; Prawat & Floden, 1994). That is, the teacher's role is to create a socially active learning setting, and subsequently develop it, and allow students to learn through it with others. The student's vision is enlarged by individual understanding and by the learning community (Gredler, 1997).

Regarding the maximisation of the student's role, the results of the current study suggest that this is necessary in order to have an effective learning method. In this present study, in the peer tutoring group and combined group, the students alternately took the parts of tutor and tutee. Therefore, students played a vital role and were central to the learning process. The results of this study highlight that the more the students' role is enhanced, the more all of their achievements, their attitude towards mathematics and their social skills were also enhanced. The results of the combined group revealed that the students in this group had the highest level of all the groups in both the attainment test and the sociometric questionnaire. Of all the groups involved in this study, the role of the students in the combined group was maximised. This suggests the significance of maximising the role of students in any learning strategy. This overall idea is consistent with the literature.

Regarding the teachers' role, while it differs from that of the students, it is equally important in the learning process. The teachers' main responsibility is to provide and maintain an appropriate and practical setting to facilitate the students' achievement of the desired level of education. Although teachers must provide tools to assist their students, the outcome may be meaningless if the students do not engage in active learning (Glaserfeld, 1983). The teachers' part here is to use prior experience to build new understanding, but the students must be involved in active learning in order to build and apply their own knowledge (Pritchard, 2013). In daily life, individuals can make use of knowledge they gained previously through learning processes or experiences to address new experiences they may encounter. This can be similar in the teaching and learning process. For example, in teaching and learning mathematics, when students may use their previous knowledge to solve a mathematics problem they have not previously been faced with.

In the social constructivism theory, the teachers are assigned to different roles according to the approach used. Broadly, their role is to assist in the classroom during discourse and organise the learning environment (Brophy, 2002), rather than to transfer mathematical knowledge to them (Irvin, 2008). Thus, social constructivist teachers must encourage their students to engage in investigative learning in the classroom (Beck & Kosnik, 2006).

The result of this current study stresses that the more teachers engage their students in the learning process and make an appropriate learning environment, the more the students benefit from their learning. The use of peer tutoring and manipulatives together seems to be one of the best ways to maximise the role of students and help teachers to build an active, exciting, encouraging, social learning environment.

7.1.3 Cognitive tools

Since the 1940s, teachers have been encouraged by the NCTM to use manipulatives with their students at all levels, with the aim of engaging them actively in the learning process. The NCTM (2000) advocates the use of manipulatives in the classroom in its publication 'Principles and Standards for School Mathematics'. The

National Education Association (2002) reports that mathematics teachers have found manipulatives to be effective. The National Centre for Accessing the General Curriculum (2001), reviewing 14 studies, concluded that the use of manipulatives had a very positive effect on students' achievement compared to conventional mathematics teaching methods. The use of manipulatives has previously been linked to improvement in mathematical achievement (Suydam & Higgins, 1977). In a national survey on educational materials, of 1,000 members of the National Education Association (NEA), 85% of elementary school teachers and 67% of teachers who taught across the age range reported manipulatives as being highly effective (NEA, 2002).

The results of this present study showed that the group using manipulatives only demonstrated a significant improvement between their pre- and post-test mean scores as well as compared to the control group in terms of mathematical achievement.

The use of manipulatives in the long-term (one year or more) was shown to be more effective than their short-term use on students' mathematical achievement. There was also an improvement in students' attitudes towards mathematics when manipulatives were used by reflective teachers. This was found in a meta-analysis of 60 studies conducted between 1954 and 1987 that examined students from nursery up to college level (Sowell, 1989). There were variable effect sizes in the Sowell study; some students yielded a large effect size, while others yielded a negative one. Various aspects of learning can be assisted by the long-term use of manipulatives. These include helping students with verbal thinking or 'thinking out loud'; assisting them in the effective discussion of mathematical ideas; improving their abilities to connect real-life problems to solvable mathematical problems; offering them opportunities to enhance their social skills; increasing their confidence, and; assisting them when making presentations (Hartshorn & Boren, 1990).

Regarding the use of manipulatives, in the interviews in this present study, students reported that they gained a deeper understanding of mathematics when manipulatives were used. This effect was observed by teachers. Both students and teachers suggested two reasons for this. First, manipulatives can assist in making a connection between theory and practical application. Students reported that manipulatives can not only assist in explaining abstract mathematical ideas and making them more understandable, but can also help students to see the link between what they see and experience in real life and what they learn in the mathematics classrooms. Hartshorn & Boren (1990) suggested that manipulatives can assist students shift from tangible to intangible thinking, and from the concrete to abstract. Further, Berk (1999) asserted that the use of mathematical manipulatives is one of the best ways of presenting abstract ideas and building a solid conceptual basis. Manipulatives help students to understand such concepts in greater depth than they previously did (Schweyer, 2000). Krontiris-Litowitz (2003) used an experimental method to demonstrate that the use of manipulatives as a teaching method and using modelling clay and beads as manipulatives improved student performance in a neurobiology class as well as enhancing their conceptual understanding and critical thinking.

The second reason suggested by the students and teachers in this current study for this better understanding is that manipulatives explain in a simple manner, concepts that students had regarded as complex. Indeed, the students reported very positively that using manipulatives assisted their teachers to explain complex mathematical concepts. They themselves consequently made use of manipulatives to explain complex mathematics in a practical way. This second reason, as suggested by the teachers and students in the present study, is also included in what Hartshorn & Boren (1990), Berk (1999), and Schweyer (2000) suggested.

In terms of the students' attitude towards mathematics, the results of this present study showed an insignificant change between the pre-test and post-test mean scores in the Attitude Towards Mathematics questionnaire for the manipulatives only group. Neither were there any significant differences between the gain scores of the manipulatives only group compared to the control group. As mentioned above, the NCTM publication, 'Principles and Standards for School Mathematics' (NCTM, 2000) clearly recommends the use of manipulatives in the classroom. Students' enthusiasm for learning mathematical concepts grows during activities involving manipulatives, the long-term use of which is also helpful in other ways. For example it can help increase their confidence when they make presentations and express their ideas (Hartshorn & Boren, 1990).

However, in this present study, the finding from the questionnaire on Attitudes Towards Mathematics was contradicted by the finding from the interviews. Both teachers and students expressed the view that the use of manipulatives had a positive effect on students' attitudes towards mathematics. Both teachers and students from the manipulatives only group suggested possible reasons for this perceived positive effect. Among these are that using manipulatives helps students to become more confident and encourages them by increasing their feelings of achievement. Further, manipulatives assisted students to engage actively in learning mathematics, with some students also reporting that they found maths lessons in which manipulatives were used more enjoyable and interesting.

The literature supports the interview findings. Rust (1999) argues that different teaching styles can assist students to understand mathematics in a number of ways. For instance, when manipulatives are being used students' attitudes change, and their enjoyment and enthusiasm increase (Heuser, 1999; Moch, 2001). The part played by manipulatives in making learning more exciting and more fun was reported in several studies (Moch, 2001; Smith, Babione, & Vick, 1999). The interview findings in this current study and the literature imply that fun and enjoyment in learning can motivate students to take an active part in their learning. This, in turn, can promote and encourage positive attitudes towards the subject being studied.

In this respect, social constructivists hold that every learner plays a significant role in the learning process, acting as learner and teacher at the same time (Philips & Soltis, 2004). According to the social constructivism theory, the learner can interact with other learners in the social learning environment, making use of cognitive tools such as hands-on and manipulatives (Gredler, 1997; Prawat & Floden, 1994) to give meaning to their social learning process. Similarly, Gredler (1997) asserts that the learners are part of a learning environment that is created and developed by them. Hence, on previous evidence, the use of manipulatives should have a positive effect on students' attitudes towards learning mathematics, although care should be taken to ensure they are used appropriately.

Conversely, certain students reported that using manipulatives could be 'annoying' and 'boring', as a result of poor social communication in lessons. This emphasises the importance of using an effective social learning method together with the use of manipulatives, as discussed previously, in the first section. Manipulatives are not effective alone, but need to be used in a social manner, in such a way as to encourage students' learning and increase their active participation in and enthusiasm for the subject.

In terms of students' attitudes towards their learning partners, the results of this research study revealed that the group using manipulatives only showed no significant increase from the pre-test to the post-test mean scores in the Attitude Towards Learning Partner questionnaire. The change between the mean of the gain scores of the manipulatives only group compared to the control group was also insignificant. Hartshorn & Boren (1990) suggested that the use of manipulatives offers students the opportunity to enhance their social skills. The students taking part in the manipulatives group in this current study did indeed show positive development in their social relationships. However, there was no significant change in attitude towards their learning partners. In contrast, in the interviews, the students from the manipulatives only group reported that they felt positive towards their learning partners, although their positive feelings were less strong than those of the students in the group using peer tutoring and manipulatives together. Students expressed their positive attitudes towards their learning partners after using manipulatives in various ways. They reported that they had started to enjoy learning with other students since they began using manipulatives and that using manipulatives was their first choice for helping to teach other students. They also demonstrated greater willingness to communicate with other students. Reflective teachers are required to use manipulatives to encourage students fully, and in particular, socially. Stein & Bovalino (2001) stress that good and effective learning using manipulatives cannot be ensured unless the latter are supported by a thoughtful teacher who knows how to make use of them effectively. Skill is needed to allow students to benefit from the use of manipulatives and it is crucial that the teachers involved are both knowledgeable and reflective. The researcher in this present study observed that certain teachers working with the groups using manipulatives only were using them in a sociable way. This could be a possible reason for there being only a slight positive change in the students' attitudes towards their learning partners in the manipulatives only group.

Only a few studies have examined the effects of using manipulatives on students' attitudes towards their learning partner, and these studies advocate the use of manipulatives with a social learning strategy. Integrating the use of manipulatives with an effective collaborative learning method is the key to obtaining the greatest social advantage from the use of manipulatives.

Concerning students' social relationships, the results of this present research study show that the manipulatives only group showed a significant change between the pre-test and post-test mean scores in the People in Your Class questionnaire. This group also showed a significant difference in the mean of the gain scores, as compared to the control group. The use of manipulatives offers students opportunities to enhance their social skills (Hartshorn & Boren, 1990). In addition, as suggested by NCTM (2000) and Shaw (2002), both students' social relationships in general and their communication skills in particular, can be enhanced, which in turn improves their learning of mathematics (NCTM, 2000; Shaw, 2002).

During the interviews in the present study, students from the manipulatives only group reported that they enjoyed learning in a social environment. It appears that the manipulatives led to the development of opportunities for unstructured cooperative learning. The manipulatives were the students' first choice for teaching mathematics to each other. They started to enjoy increased communication with each other when they began to use them. Teachers reported that the use of manipulatives helped students to become more actively involved through working cooperatively with each other in lessons, as well as assisting them to benefit from each other's knowledge and experiences. However, not all students used manipulatives in a social context; some preferred to use them to learn independently. The different perspectives explain the significance of using social learning methods, such as the use of peer tutoring, to optimise the social benefit to students' social relationships of using manipulatives.

In conclusion, although the use of manipulatives as a cognitive tool appears to improve different aspects of the students' learning of mathematics, the findings show that comprehensively, an important learning factor is missing when manipulatives are used on their own. This factor is a planned social learning method such as peer tutoring. While there was an improvement in students' learning and social skills and unplanned social activities appeared when manipulatives alone were used, the findings suggest that when manipulatives are used together with a planned social learning method, the students' learning of mathematics and their social skills can be improved to an even greater extent. In addition, there may be a greater effect on the students' attitude towards mathematics and their attitude toward their learning partners if manipulatives were combined with social learning method such as peer tutoring, as suggested by the literature and by the qualitative findings in this current study.

7.1.4 Social learning method

The social learning method is one of the most important elements to be included in an effective learning strategy. In this study, peer tutoring is used to represent the social learning method. According to the results from this study, there was a significant change in the peer tutoring group between the pre-test and post-test mean scores. There were also significant differences in the mean of the gain scores of the peer tutoring group and the control group. A number of researchers, such as Topping (2005) have found evidence to indicate that varying forms of peer learning are effective on different occasions, while others, e.g. Fuchs et al. (1997) and Johnson et al. (1998), have indicated that peer tutoring on a large scale has had very positive effects on students' learning.

Topping (2005) also showed clear evidence that students' academic achievement is enhanced by cooperative learning and peer tutoring. A thorough understanding of the curriculum content is reported as a further benefit. The social interdependence theory holds that the achievement of individual students' goals is affected by the actions of other students in the learning process (Johnson, 1970; Johnson & Johnson, 1989).

That is, there is an association between improved attainment and the social advantages that derive from cooperative interaction.

Harris and Sherman (1973), conducted a study to examine the mathematical performance of two groups of students at elementary level, one of which incorporated peer tutoring into their learning and the other of which did not. The results showed that, at the end of an academic quarter, the students in the scores of the peer tutoring group were higher than those of students in the control group. Similarly, Pigott et al. (1986), in their study on the effect of peer tutoring in a fifth level (aged 10 and 11 years old) classroom, in which each treatment group of four students was assigned a different role in an arithmetic drill, also found that the use of peer tutoring positively had a positive effect on students' attainment. Further, the result of the study of Kamps et al. (1994), investigating students' attainments in reading, showed that the students who engaged in peer tutoring demonstrated increased understanding. Vincent (1999) stated that it was well established that student achievement and self-esteem, as well as general school climate could be improved by well-planned peer tutoring programmes. The result of Tymms et al.'s (2011) study involving 129 elementary schools in Scotland, conducted over a two-year period, showed that there was a positive effect on students' attainment in both reading and mathematics from their assignment to peer tutoring.

The literature on the effects of using peer tutoring on the students' attainment in mathematics was supported by both the quantitative and qualitative data in this present study. The qualitative part of this study gave both teachers and students the opportunity to express their views on the use of peer tutoring and to offer in-depth details about its use in learning mathematics. From the qualitative data, particularly the interviews in this present study, both teachers and students from the peer tutoring group expressed their perceptions of the reasons why peer tutoring had a positive effect on learning mathematics. Teachers reported that after peer tutoring, students' attainment in maths exams was higher, while students in the peer tutoring group confirmed that their understanding of mathematics had improved, and that, indeed, they sometimes understood maths better when they were taught by their student partners than by teachers. Teachers confirmed that peer tutoring had enabled students to develop a deeper understanding of mathematical concepts and to demonstrate a greater ability to solve problems and explain them to other students.

According to the students, this improvement in understanding was due to two factors. One was that their classroom partners helped them to understand the questions better, which had a positive effect on their ability to answer them, while the second factor was simply discussion with their partners. Teachers observed that students were spending some of their free time at school to help each other study mathematics and that they appeared to be able to use simple vocabulary with which to explain the subject. This is consistent with the social interdependence theory, mentioned previously, which holds that a student's achievement is influenced by other students' actions in the learning process (Johnson, 1970; Johnson & Johnson, 1989). Further, students have the same goal but enter into friendly competition with each other ways to reach this common aim.

Active learning was one element that the students in this current study have as assisting their improvement in maths. They were more engaged in the learning process when peer tutoring was included in it, and appeared to feel they had a more active and important role in the learning process when peer tutoring was used.

According to Philips and Soltis (2004), every learner should participate effectively in the learning process. Brophy (2002) suggested that students should have a greater role in the learning process and that the teachers' role should be to manage the classroom discussions and learning environment, while Price (2006) asserted that teachers should create an appropriate creative learning environment in the classroom. There are many studies supporting the idea that peer tutoring results students' greater engagement with their learning as well as assisting teachers to develop an active and creative environment which will stimulate learning. There is evidence that the use of peer tutoring has a positive effect on teachers' performance (Olmscheid, 1999; Kourea et al., 2007) and can assist students to become more engaged in the classroom academically (Greenwood, 1991; Olmscheid, 1999).

In this present study, teachers involved in the peer tutoring group reported an improvement in both their own performance and their students' engagement with learning. The students involved in this present study stated that the use of peer tutoring enhanced their learning skills, as they now discussed ways of to resolve mathematical problems without giving each other the answers. Further, they had gained a greater understanding of the need that other students had to understand how to solve the problems rather than simply to be given the answers. This was an important development made by the fourth grade students when using peer tutoring. Students reported that they felt more encouraged to learn mathematics when peer tutoring was used in class. This encouragement, a result of the strengthening of their social relationships with the other students as well as with their teachers, had an effect on their achievement.

This idea is the central to social interdependence theory in that the social relationships among students has the significant effect of encouraging them to engage with learning. A number of empirical studies have suggested that there are direct and indirect associations between social relationships and academic achievement outcomes when peer learning methodologies are used in the learning process (DiPerna et al., 2001; Zins et al., 2004). Roseth et al. (2009) carried out a meta-analysis of 148 studies involving 17,000 students, and found positive effect sizes in students' overall academic achievements (ES=0.46) and the quality of their social relationships (ES=0.48) for those involved in cooperative learning compared to those involved in isolated, individualistic learning. Roseth et al. (2009) further identified significant relationships between peer attraction and achievement outcomes. They found that students attained higher scores and had stronger and more extensive social relationships when teachers incorporated cooperative learning into their teaching.

The results of this current study revealed that the five key factors emerging from the sociometric questionnaire predicted the post-test results of the Attainment Test in the peer tutoring group. This highlighted the effective part played by role social relationship in enhancing students' achievement in mathematics. These results are consistent with DiPerna et al., 2001; Zins et al., 2004; and Roseth et al., 2009.

Students in this present study also reported that they enjoyed the time they spent learning mathematics and would like to have more maths lessons each week. Further, they indicated that they had begun to learn mathematics cooperatively both inside and outside school. This enjoyment can be linked to greater engagement in the classroom, enhanced social relationships with other students in the maths classes, and the friendly competition associated with peer tutoring. The students also reported that they obtained greater benefit when they took the part of tutor rather than tutee during peer tutoring. They attributed the improvement in their understanding and learning skills to this.

Cook et al. (1986) conducted meta-analysis of 19 RCTs, which yielded 74 effect sizes. This analysis suggested that the tutoring programmes generally affected the students positively. The gains on attitude measures of both of tutor and tutee were greater than those measured by self-concept and sociometric instruments. Indeed, several studies reported that students' attainments and self-esteem were enhanced by the use of well-planned peer tutoring (Vincent, 1999). Students participating in this present study demonstrated a considerable ability to explain their ideas regarding the benefits of peer tutoring, evidence of their high self-esteem.

The results of this present study highlight that the achievement, social relationships, engagement with learning, and incentives to learn are positively affected for all students when they learn with peer tutoring and that their academic achievement is in turn positively affected by all these factors. Further, the results of the study reveal that there were no significant differences between the pre-test and post-test mean scores for the group using peer tutoring only. Neither were there any significant differences between the means of the gain scores of the group using peer tutoring only and the control group. Topping (2005) offers evidence to suggest that various forms of peer learning are effective on different occasions. A number of researchers (e.g., Fuchs et al., 1997; Mathes et al., 1998) have shown that peer tutoring on a large scale enhances students' attitudes towards their learning subjects. According to Roseth et al. (2009), students' positive social relationships enhance their communication skills. This subsequently improves students' achievement and thus increases their learning energy, completing the circle by the exponential development of their social relationships. Topping (2005), referring to the effects of peer tutoring, stated that there may also be affective changes in attitude towards the school, the teacher, the other students in the class and the subject itself and that peer tutoring can also increase the appeal to students of the subject they are studying.

During the interviews in this present study, both teachers and students from the peer tutoring group offered explanations for the positive effects of students' attitude towards learning mathematics of the use of peer tutoring. Students perceived mathematics to be an easier subject than they had previously thought it to be, as they found it easier to understand the explanations of their partners than those of their teachers. The students appear to communicate using simple language, allowing them to understand each other well.

Kamps et al. (1994) observed that students showed greater understanding after engaging in peer tutoring. The social interdependence theory associates students' actions with those of other students in the learning process (Johnson, 1970; Johnson & Johnson, 1989). The students' reports in this present study are consistent with the findings of Kamps et al. (1994), Johnson (1970) and Johnson and Johnson (1989). That is, the enhancement of students' communications about maths was concomitant with an increase in their positive attitude towards the subject.

The students in this present study reported that they enjoyed learning maths much more when peer tutoring was involved, and how much more they had come to appreciate the subject itself, even to the extent of wanting to specialise in it later. Further, this enjoyment motivated them to share their experience of and pleasure in this method of learning with others, both in and outside school. Moreover, the friendly competition emerging from students' shared aims led to greater engagement in and enjoyment of their learning. They also placed greater value on the subject, becoming more aware of the importance of maths in everyday life and of how it improved their thinking skills. In addition, teachers also noticed that students were not only more respectful towards them, but also showed more engagement with and enjoyment of the subject.

This present study showed that the greater the engagement of the students with their learning, the more they understood, valued and enjoyed it. These are all interdependent factors associated with their newfound positive attitude to maths and to the social interdependence theory. The students also expressed several interesting ideas concerning the psychological effect, both direct and indirect, that the use of peer tutoring had on them. Among these was a positive increase in their self-confidence and self-reliance. They explained this change in various ways: they worked more independently at their maths than previously, and with increased skill and ability, which they attributed to their training and preparation having given them more confidence. They also perceived peer tutoring to have developed their leadership skills.

Miller et al. (2010), Topping (2005) and Vincent (1999), among others, found that peer tutoring could be used to increase students' self-esteem. In this respect, Vincent (1999) stated that research had established over a period of many years that student achievement and self-esteem, as well as overall school climate, could be improved by well-planned peer tutoring programmes.

Although the qualitative findings of this current study support the findings of the literature discussed above in terms of the students' increase in both self-esteem and self-reliance through the use of peer tutoring, the quantitative findings of this study contradict these findings.

In terms of attitude towards their learning partner, the results of this present study showed an insignificant increase between the pre-test and post-test mean scores in the Attitude Towards Learning Partner questionnaire the group using peer tutoring alone. There were no significant differences between the gain mean scores of the group using peer tutoring alone and the control group. Nonetheless, cooperative learning methods should maximise important communication and scientific thinking skills, thus assisting both teachers and students by the creation of a social environment in which students are able to engage in constructive thinking and develop their understanding. This, in turn, enhances the interactivity between them (Chin & Brown 2000; Jones & Carter, 1998; Meyer & Woodruff, 1997; Millis, 1995; Resnick & Klopfer, 1989; Wood, 1992). In the interviews with the peer tutoring group in this present study, students reported having positive attitudes towards their learning partners, and that after the class they asked each other to comment on the quality of their teaching performance. This type of question suggests that the partners developed close relationships and friendly competition. They reported that peer tutoring had strengthened their social relationships with their learning partners and that these relationships continued to develop, both inside and outside school. They further indicated that they appreciated the help they had received and stressed their willingness to assist other students. The teachers involved confirmed that they had noted positive changes in the relationships between learning partners.

Thus, it can be seen that the qualitative part of this present study is in agreement with the literature discussed, although the quantitative part contradicts it.

Regarding the students' social relationships, the results of this present study show that there was a significant change between the pre-test and post-test mean scores in the People in Your Class questionnaire in the group using peer tutoring only. There was also a significant difference between this group and the control group, with the former scoring more highly than the latter. According to Johnson and Johnson (1999), forms of cooperative learning led to students developing stronger and more extensive social relationships with other students with special needs and of different ethnicities. These forms maximise the requisite communication and scientific thinking skills. They assist both teachers and students by the creation of a social setting conducive to the development of students' thinking and understanding which, in turn, enhances their interaction both with their teachers and with other students (Chin & Brown, 2000; Jones & Carter, 1998; Meyer & Woodruff, 1997; Millis, 1995; Resnick & Klopfer, 1989; Wood, 1992). There is evidence that students' social and behavioural skills can be positively affected by peer tutoring. Topping (2005) asserts that peer learning promotes personal and social development. In a similar vein, Tolmie et al. (2010), in a study involving 24 Scottish schools, found that both cognitive science test scores and social relationships improved when collaborative learning was used.

Students in this current study reported that the use of peer tutoring in learning mathematics had an effect on their friendship patterns. After peer tutoring was introduced, they had begun to make more friends both in and out of the classroom. Similarly, teachers observed that there had been an improvement in relationships between students since the application of peer tutoring in their lessons, and that the students were making more friends. The teachers attributed this to a perceived improvement in the students' interpersonal skills, leading to the development of friendship-building skills.

According to Topping (2005), when students learn through peer tutoring, they employ several valuable communication skills, such as listening, explaining, questioning, summarising, speculating and hypothesising. In a similar vein, Fitz-Gibbon (1988) asserts that students who learn using peer tutoring, whether as tutor or tutee, work together and communicate effectively with each other as they have to use their own words to explain ideas and concepts.

As students made more friends, their friendships also became stronger, particularly inside the school. This is supported in this current study, in which the students reported that they were spending more time together both in and out of school and were that their friendships were more enjoyable than they had been previously. Teachers in the present study supported this, stating that they had noted their students' growing enjoyment in their friendships, which became stronger each day. They also reported several personal stories their students has told them about their happiness resulting from the effects on their friendships of peer tutoring. For example, one teacher stated, *"My students told me a number of stories of making new friends in and out of school, how their friendships developed, and their pleasure in* *these experiences."* Teachers observed students' behaviour growing increasingly cooperative as they assisted each other with their homework. The students did not share their answers but taught each other how to find the answers. Moreover, students also appeared to be more satisfied with the social atmosphere in the classroom. A social peer tutoring group was also established in one school with the goal of improving academic and social standards. The establishment of this group indicates the enjoyment and satisfaction of students. The relationship between teachers and students also became more social and active.

The results of this present study are consistent with those of the literature regarding the use of peer tutoring and the improvement of both the quantity and quality of students' social relationships.

In conclusion, although the use of peer tutoring as a social learning method appears to improve various factors of the students' learning of mathematics, the findings show that comprehensively, an important learning factor is missing when peer tutoring is used on its own. This factor is the use of a cognitive tool such as manipulatives. While there was an improvement in students' learning and social skills when peer tutoring alone was used, the findings suggest that when peer tutoring is used in conjunction with a cognitive tool, the students' learning of mathematics and their social skills can be improved to an even greater extent. In addition, there may be a greater effect on the students' attitude towards mathematics and their attitude toward their learning partners if peer tutoring was combined with cognitive tools such as manipulatives, as suggested by the literature and by the qualitative findings in this current study.

7.1.5 The use of peer tutoring and manipulatives together in learning mathematics

The results from this study showed that the group using manipulatives and peer tutoring combined had the greatest and most significant change between the pre-test and post-test mean scores, as well as compared with the other experimental groups and the control groups. There is already evidence that the use of manipulatives and peer tutoring separately can have a positive effect on students' academic achievement, but that their combined use is the optimum method of maximising the usefulness of both, and that groups which did so scored significantly better in the Attainment Test than groups using them separately.

Manipulatives are useful if certain factors are taken into consideration. Clements (2000) criticised their use on the grounds that, although they can play a useful part in teaching mathematics, both teachers and students should be aware that they should use them for particular purposes, and in a sociable manner, which has not always been the case. Moch (2001) discussed the effects of using manipulatives on improving skills in the various branches of mathematics, emphasising that with the use of manipulatives, students' test scores improved by 10% in just 18 hours over seven weeks. The study noted that teachers used several apparently effective teaching strategies including discussion and lecturing, although it did not state the amount of the latter that was employed when the manipulatives were used. However, it can be concluded from Moch's study that the use of manipulatives in a sociable manner enhances students' communication skills and this will therefore be a more effective strategy than using them for individual learning.

Stein and Bovalino (2001) concluded that the conversations that took place between the students are typical of the active learning that takes place when using manipulatives. The aim of Stein and Bovalino's (2001) study was to present examples of effective ways of using them, and both discussion and writing were linked to their use. However, it has also been suggested that materials such as manipulatives should be used at the same time as peer tutoring in learning mathematics. Barley et al. (2002) state that successful peer tutoring in learning mathematics typically includes three main elements: training the students to act as tutors and tutees, so they understand the process of peer tutoring; involving well-structured activities in which the students can interact socially and using materials such as manipulatives. Students should act sometimes as tutor and at others as tutee; therefore, training them to understand both roles is crucial. Well-structured activities are equally important in any successful peer tutoring; hence, teachers should plan their lessons and prepare the materials required. As the involvement of materials such as manipulatives is very important if the advantages of peer tutoring in mathematics are to be maximised, it is suggested that teachers themselves should provide these manipulatives when they use peer tutoring.

While the use of materials and peer tutoring together in learning mathematics was suggested in the literature, in some of the latter it was not clear what types of material teachers should present to their students or the manner in which these materials should be used. Only a very few studies have mentioned manipulatives as materials to be used in conjunction with peer tutoring in learning mathematics.

Barone and Taylor (1996), in a field study at Fulton Elementary School in Aurora involving 440 students from mixed ethnic backgrounds, recommended that teachers should prepare their own manipulatives and train their students to teach each other when they use peer tutoring, and that the students' self-esteem, sense of responsibility, skills, motivation, academic achievement, awareness of the needs of others and appreciation of their teachers were all increased when they learned mathematics using peer tutoring with manipulatives. Teachers were enthusiastic when they saw the improvement in their students' learning skills.

Pickett's (2011) unpublished action research study on one fourth grade (aged 10 and 11years) class of twenty students (ten male and ten female) of mixed ethnicity in Hunter Street Elementary School in York, South Carolina, investigated the effect of using peer tutoring on student achievement. It similarly suggested that manipulatives and peer tutoring should be used together since such achievement, and students' attitudes towards both mathematics and their learning partners, were statistically improved after the intervention.

Barley et al. (2002), Barone and Taylor (1996), and Pickett (2011) also recommended that manipulatives and peer tutoring should be used together, and their results clearly suggested that this is effective in several ways. However, these studies did not specifically compare the use of peer tutoring and manipulatives both separately and together in learning mathematics. These studies may have recommended the use of the two together, depending on the general recommendations made in studies in mathematical education and by institutions and educational bodies, which only identified the use of manipulatives as significant in learning mathematics. Even though these suggestions are important, and applying them can advance the learning of mathematics, examining the differences between their effects, first separately then together, is necessary when trying to judge whether the use of both together increases the benefits or negates them.

Research shows very clearly that when both are used together there is a greater improvement in communication among the students, and in their mathematical achievement, than with the use of peer tutoring alone. On the other hand, the use of manipulatives was also reported to have increased students' communication skills, thereby enhancing their learning of mathematics (NCTM, 2000; Shaw, 2002).

Therefore, it is suggested that using manipulatives together with social learning strategies maximises the benefits of both. As indicated in the literature, the use of manipulatives cannot guarantee that students can benefit from them unless they are used in an appropriate way.

In conclusion, it is suggested that the manipulatives should be used as a social learning strategy and that peer tutoring in learning mathematics should involve the use of manipulatives. The use of manipulatives and peer tutoring separately was reported to have enhanced students' communication skills, enhancing their learning mediation, and thus improving their learning. However, there is a limited amount of literature addressing the effect of combining peer tutoring with manipulatives in learning mathematics.

A considerable number of studies have examined peer tutoring and manipulatives separately and a limited number have examined the use of these together. However, as far as the author is aware, this present study is the first to have examined the use of peer tutoring alone, the use of manipulatives alone, and their use in combination and to compare the three, not only between each other but between groups using them and a control group. This is therefore, the first study to conclude whether the use of peer tutoring alone, manipulatives alone, or both of these together affects students' learning of mathematics positively, negatively or at all and therefore which has the greater value in mathematics education.

From the results of this study, it can be seen that using peer tutoring and manipulatives together, as described, improved the students' achievement scores to a greater extent than using them separately. This conclusion is supported by both the quantitative and qualitative data. Both teachers and students had opportunities to describe in detail the use of peer tutoring with manipulatives in learning mathematics, and express their perceptions of combining the two in the qualitative part of this study. The results from the qualitative part of this current study agreed with the results of the quantitative data analysis, providing more detailed explanation for several issues regarding the use of peer tutoring and manipulatives together.

In the interviews in this present study, both the teachers and the students from the group using manipulatives and peer tutoring combined suggested several reasons for the use of these manipulatives and peer tutoring together having a positive effect on learning mathematics.

The students reported that they had a better understanding of mathematics when using manipulatives and peer tutoring together. The teachers agreed that students had become more adept at both solving maths problems themselves and explaining their ways of doing so to others. They appeared to be able to choose appropriate words and expressions that simplified ideas for each other. Teachers in the combined manipulatives and peer tutoring group reported better results in mathematics exams. These reasons can be linked to the social interdependence theory which proposes that a student's educational achievement is affected by other students' actions in the classroom (Johnson, 1970; Johnson & Johnson, 1989). They can also be connected to the use of manipulatives, as they facilitate the understanding of abstract ideas and their adaptation for practical use as well as assisting help students with effective verbal thinking or 'thinking out loud' (Hartshorn & Boren, 1990).

There is therefore evidence to show that the use of manipulatives and peer tutoring together assists students to communicate more effectively by simplifying the language used to identify shared goals, as well as to remain focused on the topic under discussion.

The students stated in the interviews that their engagement with their learning was more active when peer tutoring and manipulatives were used together; they were even spending some of their free time at school to study mathematics together. The teachers remarked on the resulting friendly competition as to which student could teach better. This is again consistent with the social interdependence theory, as students had a common goal and were competing amicably with each other in its pursuit (Johnson, 1970; Johnson & Johnson, 1989).

Interdependent learning processes were involved in the groups using manipulatives and peer tutoring together, as both tutor and tutee had a shared responsibility for the tasks. Using manipulatives to help them, both had to make an equal effort to work out the procedures for solving problems. It was a reciprocal process, and therefore each student had to take the role of tutor in one lesson and tutee in the next, with each trying to surpass the other as tutor in friendly competition, as they reported in the interviews. As one student stated, *"We vie with each other to see who is better."* In this case, when the students do better taking the role of tutor, so do those who take the role of tutee. All students should be thoroughly prepared for the lesson, as they will all have to take the role of tutor at some point. The result of this present study demonstrated that the quality of the social relationships between students was a predictor their achievement. This led to recognition of the connection between the cooperative interaction and social and achievement advantages, as explained by Roseth et al. (2009).

In the interviews in this current study, teachers and students reported the same active role of the learner as that suggested by Philips & Soltis (2004) and the same supporting role of the teacher as that suggested by Brophy (2002) and Price (2006). These were also plainly observed by the researcher when peer tutoring and manipulatives were used together in this study.

Using this combination also assisted teachers to construct a classroom setting which encourages active learning. While the use of peer tutoring alone has also been found to increase students' academic engagement (Greenwood, 1991; Olmscheid, 1999), it appears that using manipulatives did not negate the effect of using peer tutoring on the students' engagement. The results of this present study suggest that using manipulatives does increase the effects of peer tutoring on the students' engagement with their learning, as the group using a combination of peer tutoring and manipulatives had higher scores in the Attainment Test than the group using peer tutoring alone.

The active participation of the students in the group using a combination of manipulatives and peer tutoring together was maximised during this present study. The class was separated into pairs, with the students in each pair alternating the roles of tutor and tutee, supporting their learning with manipulatives and working interdependently to solve the class tasks. In this process, the role of the teacher is to organise the lesson and build an appropriate learning environment which will encourage the students to participate actively in their learning. Teachers must support this learning process by observing the learning and addressing any issues that arise. The role of students and their involvement was maximised and the role of teachers was minimised with the use of peer tutoring with manipulatives, as described above. The increase in the engagement and involvement of maths students was reported by both teachers and students in the combined manipulatives and peer tutoring group, as was students' resulting increased enjoyment.

Students also recognised their developing learning skills; for instance, they described how they now discussed ways of resolving maths problems without giving each other the answers directly. A significant development made by fourth grade students when using both peer tutoring and manipulatives together was that they became aware of their need of each other. This development was also reported by students in the group using peer tutoring alone, although students using manipulatives alone did not report such a development. Therefore, it can be concluded that this development resulted from the interaction of pairs and was linked to the progress that students made in their social relationships.

Students in this current study stated that they felt more encouraged to learn mathematics when manipulatives and peer tutoring were used together in class. Among the reasons for this were their feelings of more active inclusion in the learning process and enhanced social relationships with both other students and their teachers. As stated previously, this is the principal concept of the social interdependence theory, as the social relationship between students motivates students to engage with their learning (DiPerna et al., 2001; Zins et al., 2004; Roseth et al., 2009).

The results of this present study show evidence that the combined use of manipulatives with peer tutoring enhances the effects of using peer tutoring, as the students in the group using combined peer tutoring and manipulatives had significantly better scores in the Attainment Test than students in the group using peer tutoring alone. In addition, the students also reported their greater enjoyment of learning mathematics much more and stated that they would like to have more maths lessons each week. They began to work at mathematics, in and out of school. This can be connected to greater engagement in the classroom, better social relationships with other students during maths lessons and the friendly competition which arose through peer tutoring.

A meta-analysis carried out by Cook et al. (1986) on 19 RCTs gave 74 effect sizes and suggested that the tutoring programmes had in general affected students positively, with the students agreeing that those in the role of tutor gained greater benefits than their tutees. The results of this present study are consistent with the literature, which similarly found that the tutor gained more in such circumstances than the tutee.

Regarding students' attitudes towards mathematics, this present study's results indicate that the group using manipulatives and peer tutoring together showed an insignificant change between the pre-test and post-test mean scores. They also showed an insignificant in comparison to the control group in the Attitude Towards Mathematics questionnaire.

According to Barone and Taylor (1996), students reported increased self-esteem and a greater sense of responsibility, improved skills and motivation, higher academic achievement, greater awareness of needs of others and greater appreciation of teachers when peer tutoring and manipulatives were used in combination in the learning process. Similarly, Pickett (2011) found that students' achievement as well as their attitudes towards both mathematics and their learning partners, showed a statistical improvement after the intervention.

Few studies have investigated the effects of using a combination of manipulatives and peer tutoring on students' attitude towards learning mathematics, as discussed above. However, as the qualitative data suggest, the use of peer tutoring and manipulatives together appears to combine the benefits of both and, as a result, has a positive effect on the enhancement of students' attitude towards learning mathematics.

As demonstrated in the qualitative part of this present study, the use of manipulatives alone can positively affect students' attitude towards learning mathematics. However, it was also revealed that the group using manipulatives and peer tutoring combined had more positive attitudes towards mathematics than either of the groups using manipulatives or peer tutoring alone. It is therefore clear that the use of manipulatives and peer tutoring combined is the best methods of optimising the value of both in learning mathematics. Manipulatives are more useful if certain other factors are taken into consideration, and peer tutoring is more useful when used together with manipulatives. Nevertheless, both teachers and students should be attentive to the manner in which they work with manipulatives, as these should only be employed in a sociable way and for particular purposes,

The NCTM has suggested that the appropriate use of manipulatives should make students more enthusiastic about learning mathematical concepts. As discussed earlier, the social interdependence theory suggests that students' actions have reciprocal effects (Johnson, 1970; Johnson & Johnson, 1989). However, Clements (2000) has criticised the concepts of tangible manipulatives and concrete ideas.

Several explanations emerged in the interviews in this present study with both teachers and students for the positive effects of the combination of manipulatives and peer tutoring on students' attitudes towards learning mathematics. Students stated that they found mathematics to be easier because as they could understand their learning partners' explanations of it better than they could those of the teachers. Students enjoyed learning mathematics following the use of manipulatives and peer tutoring. Teachers reported that students appeared to have more enthusiasm for and greater enjoyment of maths lessons.

Students gained more respect for mathematics and found the lessons enjoyable. Using peer tutoring and manipulatives combined enhanced their understanding of the importance of mathematics in developing their thinking and in real life situations.

The use of manipulatives alone assists in increasing students' enjoyment in and enthusiasm for maths, which in turn gives them a more positive attitude towards learning the subject (Heuser, 1999; Moch, 2001; Rust, 1999; Smith et al., 1999). Moreover, it appears that when manipulatives were combined with the use of peer tutoring, the students' attitude towards mathematics improved even further.

Having fun and enjoying learning motivates students to become active learners, which encourages them to have a positive attitude towards the subject. Social constructivists hold that every student is an important part of the learning process and acts as learner and teacher at the same time. Each student participates effectively in the learning process (Philips & Soltis, 2004).

In the social constructivism theory, the student can interact with other learners in a social learning setting using cognitive tools such as hands-on and manipulatives (Gredler, 1997; Prawat & Floden, 1994). Thus, students learn sociably, while their social-constructivism skills and cognitive tools give meaning to their social learning process. The learner is involved in creating and developing the learning environment (Gredler, 1997).

Regarding the friendly competition which can arise from the use of peer tutoring and manipulatives together, it can encourage students to enjoy, value and engage more with their learning. This present study showed that the greater the students' engagement with their learning, the greater the enjoyment they gained from it, and the greater the respect they had for mathematics. It also showed that the learning process is affected by the factors of enjoyment in learning, engagement in the learning process, and greater understanding and respect for the subject.

While the quantitative results showed that there were no significant changes between the pre- to post-test scores in the Attitude Towards Mathematics questionnaire between groups, the qualitative results showed that students' attitudes towards mathematics improved when peer tutoring and manipulatives were used, both separately and together. While there is the possibility that the results of the questionnaire and the interviews differ because in the latter, the interviewees expressed what they thought the researcher wanted to hear, there are nonetheless a number of reasons to suggest that the results of the interviews might be more reliable than those of the questionnaire.

The inconsistency between these results could be due to students' inability to express their feelings in the questionnaire and their willingness to express their feelings verbally. Alternatively, the fact that the intervention was of short duration may be the reason that students' attitude towards mathematics had not improved after the intervention. Further, although the attitude of the experimental groups showed no significant change pre- and post-test, this contrasted with the attitude of the control groups, which deteriorated. This leads to the conclusion that although the involvement of interventions in learning mathematics did not enhance students' attitudes towards mathematics, it at least appeared to prevent their deterioration.

Moreover, the results of the interviews were consistent with the previous literature. In addition, the observations of the researcher in the current study gave him the clear impression that the group using manipulatives and peer tutoring together were more enthusiastic about mathematics and demonstrated greater excitement in and enjoyment of learning. In addition, both the students and teachers agreed that this was the case.

While the results of this present study showed that the group using manipulatives and peer tutoring together showed an increase between the pre-test and post-test mean scores in the Attitudes Towards Learning Partner questionnaire and an increase as compared to the control group, the change was insignificant. However, this group had the greatest positive change in the Attitude Towards Learning Partners questionnaire of all the experimental groups. The positive effect on students' social relationships of the use of manipulatives and peer tutoring combined in learning mathematics has been demonstrated, as recorded in the literature. During the interviews, the students in this group stated that they felt more positive towards their learning partners, that their friendships grew stronger and that they wanted to spend more time with each other studying maths using peer tutoring and manipulatives both in and out of school. Students acknowledged that wanting to share their time in this way was an indication of the way in which their friendships were growing. Their statements expressed the strength of the relationships that learning partners developed while using manipulatives and peer tutoring combined. The teachers confirmed these positive and developing relationships between study partners, citing as evidence their own observations of students' increasing enjoyment in their learning.

The personal relationships between pairs who participated in this study were already strong. In a wider context, the relationships between learning partners in Saudi Arabia as a whole can be considered as something that needs more time to develop. The researcher expected these personal relationships between pairs in the experimental groups to have strengthened by the end of the study, and this factor might have been more significant if the study had been longer, allowing time for this to occur. Although the personal contact between learning partners in the manipulatives group was less than in the peer tutoring group, the manipulatives group scored better in the Attitude Towards Learning Partner questionnaire. Hence, the group using manipulatives and peer tutoring together showed more positive attitudes towards their learning partners than other experimental groups. This underlines the idea that combining the two maximises their positive social effect as compared with the use of each of them alone and also improves relationships between partners, both on and off school premises.

The results of this present research study indicate that the group using manipulatives and peer tutoring together showed a significant change between the pre-test and post-test mean scores for the People in Your Class questionnaire, in comparison with the control group. In addition, the group showed a significant change between the pre-test and post-test mean scores for the People in Your Class questionnaire, as compared to either the manipulatives alone or the peer tutoring alone group. Integrating manipulatives with peer tutoring affected the students' social relationships more positively than using either one alone. It seemed that using manipulatives in social way increasingly improves students' social and communication skills, giving students more opportunity to improve their talking skills in the classroom.

The cooperative use of manipulatives give students opportunities to improve their social skills (Hartshorn & Boren, 1990), maximising the necessary communication and scientific thinking skills, and helping both teachers and students by creating a social environment in which students can think constructively and develop understanding, all of which all develops their interactivity with their teachers and other students (Chin & Brown, 2000; Jones & Carter, 1998; Meyer & Woodruff, 1997; Millis, 1995; Resnick & Klopfer, 1989; Wood 1992).

In this current study, students presented a number of interesting ideas regarding the effects on their friendships, in and outside both classroom and school, of using manipulatives and peer tutoring in learning mathematics. They started to make more friends and said they felt their friendship skills had developed as a result of using manipulatives and peer tutoring A number of students who were interviewed from the group using manipulatives and peer tutoring together observed that their friendship patterns were becoming stronger than before, they were spending more time with their friends in and out of school and were enjoying their friendships more. The social environment in the classrooms and schools had developed, all of which they were very happy with. Teachers had observed a number of similar effects of using manipulatives and peer tutoring on their students' social behaviour, and good relationships between students had increased in number and developed in depth and strength. Students had told them of their increased enjoyment in their friendships, and teachers repeated a number of personal stories they had heard from their students of their pleasure at the effect that using manipulatives and peer tutoring was having on their friendships. Teacher I09 said, *"My students described their experiences of making friends and having better friendships than before, and attributed this to using manipulatives and peer tutoring".* They also noticed students' increasingly cooperative behaviour, with Teacher I07 remarking that *"it is amazing to see pupils helping each other with maths".*

The students recognised that the use of manipulatives in a social context (peer tutoring) was really effective. As one explained, *"When I teach my peer a mathematical concept, it is much easier to use manipulatives to explain it;"* and another, *"We use manipulatives to socialise our learning in and out of the classroom, and even in our homes. It is a good experience".* The use of manipulatives in a social manner (peer tutoring) appeared to help students to socialise their learning which, in turn, improved their personal relationships and social skills. Students reported that they had changed their opinions on to how to work with other students in learning mathematics, saying they were now cooperating over sharing ways of solving maths problems. They also agreed that relationships with their teachers had become more sociable and active.

Only a few studies examine the effects of using peer tutoring and manipulatives together in learning mathematics on students' social relationships. While the studies are clear about the positive effects on students' social relationships of the use of peer tutoring alone, the effects on those relationships of using peer tutoring and manipulatives together have not previously been studied.

The results of this present research study suggest that the combined use of peer tutoring and manipulatives assist in increasing` students' communication skills, which in turn improves their relationship skills to a greater extent than the use of peer tutoring or manipulatives alone.

7.2 The social effects on academic outcomes

The results of this research study indicate that awareness of a social situation can affect outcomes. In a meta-analysis that comprised 148 studies from 11 countries, Roseth et al. (2006) found academic achievement to be strongly related to interpersonal perception for middle-grades students, while Ginsburg-Block et al. (2006) in a further meta-analysis of 36 studies of peer learning in elementary schools, identified a definite, positive correlation between social and self-concept outcomes and academic outcomes (Pearson's $r=0.50$, $n=20$, $p<0.01$). Johnson et al. (1985), in a study in the USA mid-west, found that both academic and social gains increased when cooperative learning was used in science lessons. Roseth et al. (2009), in another meta-analysis of comprising 148 studies involving 17,000 students, confirmed positive effect sizes in students' achievements (ES=0.46) and social relationships (ES=0.48) for cooperative learning as opposed to learning in isolation. Furthermore, they revealed significant relationships between peer attraction and achievement outcomes. They discussed whether students would achieve higher scores and have improved social relationships, and whether these would be seen to relate to each other when teachers structured cooperative learning into their lessons. Roseth et al. (2009) recognised that "positive social relationships increase promotive interaction, which increases achievement, which increases positive cathexis, which increases positive social relationships even more, and so forth" (p. 226). Empirical studies suggest that social relationships and academic achievement are directly and indirectly related when peer learning methodologies are applied (DiPerna et al., 2001; Zins et al., 2004).

7.3 General discussion

The result of this RCT research study showed that the experimental groups (manipulatives group, peer tutoring group, and combined manipulatives and peer tutoring group) scored more highly than the control group in the Attainment Test and in the Sociometric questionnaire. It also showed that the group using manipulatives and peer tutoring together scored more highly than the other experimental groups, with the peer tutoring only group coming second and the manipulatives only group last. In contrast, in the Attitude Towards Mathematics questionnaire between groups, there were no significant changes between the pre- and post-test scores. However, the qualitative results showed that students' attitudes towards mathematics improved when peer tutoring and manipulatives were used, both separately and together. In the Attitudes Towards Learning Partner questionnaire there were no significant changes between the pre- and post-test scores, whereas in the qualitative part of the study, the results suggested that the students' social relationships were enhanced.

According to Price (2006), it is the teachers' responsibility to produce a suitably creative classroom environment, in which 'students [can] construct their own understanding and knowledge of the world.' (Poplin, 1988).

What is needed is a focus on teachers' continuing professional development (CPD) in order to ensure the improved learning environment that students deserve. Although teachers need to be knowledgeable in the subjects they teach, pedagogical skills are even more necessary. Students should be actively and practically involved in lessons, and given opportunities to explain their thinking about mathematics. This might then help teachers to become more aware of, and reflect on, the students' knowledge and mathematical thinking skills, and rise to the challenge of developing suitable teaching environments in response.

Students, as Piaget believed, build their knowledge step by step by being actively involved in their learning processes, a view which aligns with what Philips and Soltis (2004) suggest as being the role of the learner in the learning process. Further, Vygotsky believed that learners in a social context construct their own knowledge. In the social constructivism approach, social activities have valuable roles. Each person in the social constructivism approach can simultaneously be both learner and teacher. All learners have individually important roles in the learning process (Philips & Soltis, 2004). With regard to the social constructivism theory, this active involvement can be noted in the roles of both students and teachers in the classroom. The teacher's role is to prepare the classroom environment for learning, including arranging the overall layout and providing classroom materials, and to supervise the lesson and classroom discussions.

According to Johnson and Johnson (1994), there are five main elements that contribute to effective group learning, achievement, and social, personal and cognitive skills such as problem solving, decision-making and planning. These elements are positive interdependence, individual accountability, face-to-face interaction, social skills and processing. A number of studies have indicated relationships between academic attainment and the building up of friendships, self-esteem and students' attitudes (Eccles et al., 1999; Masten et al., 1995; Parker et al., 1995). Topping (2005) stressed that there is evidence that forms of peer learning are effective. Peer tutoring on a large scale, as a number of research studies have shown, has positive effects on students' learning, (Fuchs et al., 1997; Mathes et al., 1998). According to Topping (2005), "The research evidence is clear that both peer tutoring and cooperative learning can yield significant gains in academic achievement in the targeted curriculum area." (p. 635). As Topping (2005) argued, students benefit from peer tutoring in that they consequently understand the curriculum content more thoroughly. In the social interdependence theory, the achievement of each student's goals is affected by the other students' actions in the learning process (Johnson, 1970; Johnson & Johnson, 1989). In other words, there is a link between attainment and the social advantages of cooperative interaction (Roseth et al., 2009).

The use of peer tutoring alone, as suggested in this present study, positively affected students' learning by increasing their role in the classroom and involving them actively in the learning processes. It helped them improve their social and communication skills, which positively predicted their academic achievement. The students' attitudes towards both learning mathematics and their learning partners were positively affected by using peer tutoring, as evidenced by the quantitative and qualitative data in this RCT study.

On the other hand, Perry et al. (1999), in an investigation into the nature of mathematics and the learning and teaching of mathematics involving 40 teachers who were heads of maths departments in Australian schools, found that it was necessary to train mathematics teachers in how to use mathematical manipulatives. This training should take place at both a preparatory level, that is, during their teacher training before they start teaching, and as part of their CPD during their teaching career. In addition, mathematics teachers must accept the idea that it is to their students' advantage to use manipulatives as a teaching method. In the same study, although teachers seemed to be confident in using manipulatives, they said they would appreciate more training in how to use them effectively.

The data in this study suggest that teachers should be trained to use manipulatives using a social learning strategy such as peer learning, as the results indicate that such strategies maximise the positive effects of using manipulatives. It is clear that the role of teachers is critical, in terms of achieving the greatest benefit from using manipulatives and the importance of their being aware of when and how they should use them.

Moscardini (2009), in an observational study that took place in three primary special schools in Scotland, suggested that although students with learning difficulties achieve meaningful learning when their teachers use materials, teachers should be aware of the purpose of using them and their specific effects on their teaching.

Teachers without a strong understanding of the most effective way of using manipulatives in their lessons might still be in need of support or training in how to do so. Teachers should have a clear idea of the importance of the ways in which they use manipulatives to achieve their outcomes and make mathematical problem-solving easier. Moreover, the way in which students use manipulatives should adhere to recommendations made by educational theorists, in order to help students gain the greatest advantage from their use. For example, learners must be actively involved in their learning in order to construct their knowledge base and obtain more information for themselves, rather than passively constructing their knowledge through others. A number of other studies claim that there are other steps that should be taken in order to gain such benefits (e.g., Moscardini, 2008; Baroody, 1989; Kelly, 2006).

In this respect, Kelly (2006), in an article focusing on how elementary school children use manipulatives in problem solving while working on mathematical tasks, recommends the following ten steps for making the most effective use of manipulatives.

1- Clearly set and maintain behaviour standards for students using manipulatives.

2- Clearly state and set the purpose of the use of manipulatives in the mathematics lesson.

3- Facilitate cooperative and partner work to enhance the development of mathematical language.

4- Allow students an introductory timeframe for free exploration.

5- Model manipulatives clearly and often.

6- Incorporate a variety of ways of using each manipulative.

7- Support and respect manipulative use by all students.

8- Make manipulatives available and accessible.

9- Support risk-taking and inventiveness in both students and colleagues.

10- Establish a performance-based assessment process. (p. 189-190).

Although Kelly's steps seem to be important, the data from this current study suggest that for the most effective use of using manipulatives, teachers should be aware of two main steps, rather than Kelly's ten steps. First, the most appropriate manipulatives for each mathematics lesson should be chosen, and second, a social strategy (peer tutoring) used to facilitate the students' learning. These two steps should increase the students' communication skills and ensure such communication focuses on the subject. Therefore, these two steps should enable students to obtain the full advantages of using manipulatives in their mathematics lessons. Two steps were developed in this present study, as the researcher was of the opinion that not all of Kelly' ten steps were relevant to teachers, and that some were overlapping and could therefore be summed up to two basic steps. These two steps also offer teachers the flexibility to be more creative than do Kelly's steps, which only direct teachers' performance without offering them any opportunity for creativity.

Although manipulatives alone can help students to achieve higher scores in mathematics than students who do not use them, the use of an additional effective social learning method, such as peer tutoring, helps students to gain even higher scores than students who use manipulatives alone.

Students benefit from each other during the learning process and manipulatives work to make this benefit transfer friendly (Berk 1999). Manipulatives can furthermore help teachers to build a social environment in which students can share their knowledge and experiences with each other. The use of peer tutoring with manipulatives, as this present study suggests, benefits students' learning of mathematics in Saudi elementary schools in various ways - academically, socially, and psychologically. Academically, it raises their scores and deepens their understanding of mathematics; socially, it improves their social relationships in both quantity and quality and psychologically it affects their attitudes towards learning mathematics and their learning partners, raises their self-esteem and builds their self-confidence.

In conclusion, the results of this study suggest that the use of manipulatives positively affects students' learning of mathematics, although it is clear that the use of peer tutoring affects it more positively than the use of manipulatives. Yet, the use of peer tutoring and manipulatives together showed even more positive results than using either of them on its own.

This study suggests that the use of peer tutoring with manipulatives increases students' communication skills, which in turn increase both metacognition skills that increase attainment and understanding in mathematics, and affective skills that increase the quality of students' social relationships and their self-confidence.

Teacher training in mathematics, whether before teaching at university level or while training to teach in school, should consider the use of peer tutoring with manipulatives as a teaching strategy that enhances the role of students in their learning, improves students' communication and social skills, develops positive student attitudes towards mathematics and their learning partners and raises students' academic achievements.

7.4 Conducting RCTs in Saudi Arabia: the specifications and challenges

This current study appears to be the first RCT to be carried out in the education field in the Saudi context. It seems that it is important to discuss the specifications and challenges that researchers may face when conducting RCTs in Saudis Arabia. This study can offer a guideline to researchers in Saudi Arabia on how to apply RCTs in educational studies. The following sections will discuss these specifications and challenges.

Although the results of RCTs are considered to be evidence of the highest order (Tymms et. al., 2011), conducting RCT researches is unusual in educational studies (Topping et al., 2011). Tymms et al. (2011) suggested that the use of RCTs can be helpful in influencing the creation of educational policy at the highest level, and is highly recommended in developing such policy. Further details on the specifications and challenges of conducting RCTs can be found in the literature review chapter.

Although the use of RCTs in educational studies is, generally speaking, rare, it is even more so in the Saudi context, where only a few have been undertaken, for a number of reasons. First, it can be costly, as travelling between schools and printing papers can be expensive. Preparing for an RCT is very time-consuming. The researcher needs a range of management skills, including time management and diplomatically interacting with the education authority and the selected schools' senior staff, teachers and students. Timing is crucial: every minute of every day must be used – there is no time to repeat anything. Everything must be meticulously planned and carried out at the allocated time - the paperwork, sampling, pre- and post-tests, learning strategy application and interviews. Should anything be omitted, the whole study would be jeopardised.

Despite all these drawbacks, which can make carrying out an RCT very difficult to manage in Saudi, this researcher would nevertheless encourage PhD students and researchers to undertake such studies since there are many advantages in doing so. Although only a few RCTs have been carried out in Saudi schools, in AlAhsa city the education authority, and senior staff, teachers, and students in the schools involved in this RCT, participated extremely effectively, enthusiastically and cooperatively. They respected the idea of such research and enjoyed being part of it. Even after the fieldwork trip was over, the teachers still kept in touch with the researcher, asking about the learning strategy and eager to know the results. They were all open-minded, sharing views and opinions, and were not embarrassed to ask about the teaching processes and anything else that arose. These are all good reasons for encouraging more researchers to undertake such studies, in order to provide the educational authorities in Saudi Arabia with strong evidence that could positively enhance education in Saudi.

In the researcher's opinion, this present study can be useful to the education authorities in Saudi Arabia, as it suggests that training teachers to use manipulatives and peer tutoring together in Saudi schools would be an effective strategy to improve students' learning, not only in mathematics, but also in other subjects. In addition, this present research may encourage the education authorities to support more studies in this field, in order to gather more evidence of the benefits of this strategy for Saudi students in different age groups.

7.5 Limitations of the study

The application of RCTs is comparatively rare in education studies, although their results are widely accepted by a number of organisations and at policy level. No study is without its limitations. In this section, the limitations of this study are presented and discussed.

7.5.1 Methodological limitations

Randomisation issues

Another limitation of this study was that it required complex design and analysis, as the unit of allocation was a group rather than an individual. Hutchison and Styles (2010) suggested that if the unit of allocation for interventions is the class, this produces separate units of allocation, as the number of classes and the unit of analysis should be the unit of allocation. Therefore, the conclusions drawn from a randomisation process may not be as accurate as if the unit of allocation had been individuals.

However, there are a number of reasons for the researcher having been unable to allocate individuals to the interventions. One of them is that the participants were studying in different schools scattered around the city. The interventions started in the middle of the school term and the researcher had no authority to move students around, either between classes in the same school or between schools.

Sampling issues

The number of classes participating in this study could be considered large for a PhD study. However, a number of RCTs considered a larger sample size, such as Tymms et al. (2011) who carried out an RCT study over two years involving 129 primary schools and Topping et al. (2011) who involved 86 co-educational and mixed-ability Scottish primary schools in a two-year RCT.

Another limitation of this RCT is that only male students in their fourth year, aged 10-11, were chosen to represent elementary school students in this study. These were not compared with female students, as the education system in Saudi Arabia segregates male and female students in separate schools, with the male schools administrated and taught by male teams and the female schools administrated and taught by female teams. As the researcher is a male, he was not able to access female schools for religious and cultural reasons. This RCT required personal contact with teachers, accessing the schools to supervise the interventions, training teachers and making observations. For these reasons, the researcher was obliged to carry out the RCT with male students only. In this light, it is recommended that shared RCT projects between male and female researchers be conducted to compare gender differences.

Another limitation of the study is that the number of participants in the control group was greater than those in the experimental groups. As the classes had been chosen randomly and there is no standard class size in Saudi schools, the researcher found larger class sizes for some of the control group classes. This was unavoidable.

Clustering

According to Bland (2004), a cluster RCT is a type of RCT in which there is randomisation of groups of subjects rather than individual subjects.

Cluster RCTs have several advantages over individually RCTs, such as the ability to study interventions that cannot be directed toward chosen individuals and the ability to control for "contamination" across individuals (for example, a change in the behaviour of one individual may influence other individuals to change their behaviour) (Edwards et al., 1999).

However, cluster RCTs have some disadvantages in comparison to individually RCTs. Among these are more complex design and analysis, and the need for a greater number of participants to obtain an equal statistical power (Campbell et al., 2004). Specifically, cluster randomised designs introduce dependence (or clustering) between individual units sampled. An example would be an educational intervention in which schools are randomised to one of several new teaching methods. When making comparisons between differences in outcome obtained under the new methods, researchers must consider the fact that there is more likelihood of two students sampled from a single school being similar in terms of outcomes than two students sampled from different schools (Torgerson & Torgerson, 2013). Multilevel or similar statistical models are generally used to correct for this non-independence.

Although there might be a cluster effect in this research, the number of classes participating in this study is low for a cluster RCT to be carried out. As this is a PhD study and the researcher was managing the project alone, the possibility of extending the number of classes in order to do a cluster RCT was limited.

Therefore, it is suggested that more RCT research studies should be done in Saudi Arabia on a large scale and taking account of data clustering in the study in order to avoid this limitation.

Fidelity Issues

Although there was distance supervision by the researcher in order to observe the intervention, and the senior staff and mathematics teachers in both schools were so helpful and cooperative, it would have been preferable if the researcher had had time to supervise the different tests himself and the opportunity to control the test conditions and intervention processes in all the schools and groups. The researcher made strenuous efforts to train the teachers who volunteered for this research study, and undertook a number of observational visits to watch the learning processes in action in the different classes. However, these visits cannot guarantee that the implementation of the new processes by the schools and teachers will be as stipulated, as, when the researcher is not present, teachers can proceed in their own way which might be quite different from what the researcher has trained them to do. Therefore, in practice, the researcher has no control over the teachers.

7.5.2 Implementation limitations

School environment issues

The researcher made efforts to select both Aramco-built schools and government-built schools for this study. The differences between the two types of school are explained in Chapter Four. Further, the research was carried out in schools that had different building styles and qualities, which could affect teaching and learning either positively or negatively. Although there is no reported evidence that different types of school building affect students' performance in Saudi Arabia, a study by Barrett, Zhang, Moffat and Kobbacy (2013), conducted with 751 students from 34 classrooms across seven primary schools in Blackpool, found that school layouts can affect students' development positively or negatively by as much as 25 percent.

Intensity Issues

The application of learning methods in this study lasted only 12 weeks. It would have been preferable if the interventions had taken longer, in order to give the results more validity. A number of RCTs in peer tutoring were undertaken over a longer period of time: for example, the studies of both Tymms et al. (2011) and Topping et al. (2011) as reported above, were undertaken over two years. A number of RCTs that were undertaken or are currently in progress, by the CEE and IEE were or are being conducted over two to four years. However, as this is a PhD study, and because the time allocated to the fieldwork trip that was funded by the Saudi government was limited, the researcher decided to apply the interventions for 12 weeks. Other reasons for this decision were that the researcher had to do a great deal of paperwork within the field trip time, and that the two units of the fourth grade mathematics book that were included in this study were scheduled to be taught over a period of 12 weeks.

According to Tymms et al. (2011), peer tutoring is reported to be positively effective when it is applied for 30 minutes per day, five days per week. Higher levels of ‘‘intensity’’ of a class-wide peer tutoring programme that was conducted over 19 weeks increased spelling outcomes (Greenwood, Terry, Arreaga-Mayer, & Finney, 1992). However, according to Fuchs, Fuchs, Mathes, and Simmons (1997), levels of intensity of intervention often differ between studies.

The interventions in this study were applied for 30 minutes per day, on one day per week. A number of reasons led the researcher to make this decision. One of them was the study budget which made it difficult for him to provide enough resources for more days of intervention. The other reason was that the Saudi teachers had not come across such changes in their methods of teaching, and the application of the interventions just once a week would encourage them to take part in the study. Despite the application of the intervention being limited to 30 minutes once a week, the results of this study indicated effective outcomes and interventions.

7.5.3 Management limitations

Cost

Carrying out such an RCT study was expensive, because a considerable number of printed papers needed to be formatted in a large font size suitable for fourth-year students. It was also necessary to arrange training events for the teachers, travel between the participating schools and make extensive phone calls, all of which were costly.

Pre- and post-testing climate

The management of the pre- and post-testing of all study instruments was somewhat complex. Although there was distance supervision of the application of these tests and the senior management teams and classroom mathematics teachers in the schools were helpful and cooperative, direct supervision of the tests by the researcher would have provided better oversight of the tests and helped to standardise the classroom environment in which they were administered.

There were four groups in this research; namely, three experimental groups and one control group. In the first pilot study, two classes were involved and in the second, main study there were six classes. The large number of participants and the fact that classes were in different schools made the management of the pre- and post-testing of all study instruments very problematic, particularly in scheduling and being present at the schools for the testing. There was also an issue of uneven starting values of measures across conditions.

7.5.4 Limitations of the findings

Although the researcher is confident that the analysis of the results is, broadly speaking, accurate, it may not individually represent all those who participated in it. The results of this study showed large effect sizes in both the Attainment Test (partial $ή^2$ = .520) and the Sociometric questionnaire (partial $ή^2$ = .649); however, a small effect size emerged from both the Attitude Towards Mathematics questionnaire (partial $ή^2$ = .014) and the Attitude Towards Learning Partner questionnaire (partial $ή^2$ = .009). The effect sizes can explain what percentages of the variance can be explained in the study population. With only 1.4% of the variance explained in the study population in the Attitude Towards Mathematics questionnaire and 0.9% of the variance explained in the study population in the Attitude Towards Learning Partner questionnaire, the results of these two instruments cannot be generalised.

8 CHAPTER EIGHT: CONCLUSION AND RECOMMENDATIONS

This, the final chapter of the thesis, draws the conclusions of the research and makes recommendations for future researchers, education policy makers, and teachers. This chapter will be structured as follows. It will begin with the statement of the problem in Section 8.1. This will be followed in Section 8.2 by the summary and interpretation of the results. Next, in Section 8.3, the methodology used in this thesis will be reviewed and critiqued. Section 8.4 will discuss the implications of the research and Section 8.5 will conclude the thesis by making recommendations for the Saudi government, future researchers, teachers, and teacher educators.

8.1 Statement of the problem

The aim of this study was to develop, pilot, test and research mathematical pedagogies to improve attainment in schools in Saudi Arabia. The pedagogies explored included the use of manipulatives and peer learning. The thesis reports the investigation which was carried out using a factor design to explore the effects of incorporating resource-led and peer learning into teacher pedagogies. Outcomes measured included attitudes towards mathematics, attitudes towards learning partners, as well as mathematical attainment, social relationships, and the role such relationships play in relation to mathematical attainment.

8.2 Summary and interpretation of the results

8.2.1 The effect of using peer tutoring and manipulatives, both separately and together, on students' attainments

An RCT was conducted to examine whether there were significant increases in the mathematics attainment between the experimental groups compared with the control group. The results of the RCT were analysed using a repeated measures ANOVA to assess whether there were significant increases in the mathematics attainment from the pre- to the post-test in each group, then one-way ANOVA with Bonferroni correction *post hoc* comparisons were used to assess whether there were significant differences in the mathematics attainment between the groups. The analysis indicated that all the experimental groups in this study scored more highly in the Attainment test than the control group. The eta squared effect size was large (partial $\acute{\eta}^2$ = .520), which indicates that 52% of the variance is explained by the model in the population. Both the peer tutoring group and the group using peer tutoring and manipulatives together gained significantly more than the manipulatives only group, while the group using manipulatives and peer tutoring together scored more highly than the group using peer tutoring alone. These results are supported by both the qualitative data in this study and the previous studies, suggesting that both manipulatives and peer tutoring on their own are effective in improving students' attainment in mathematics. Although limited number of studies examined the effect of using both peer tutoring and manipulatives together on students' attainment, the results of this study are supported by these studies examining the effects of using both peer tutoring and manipulatives together.

In the qualitative part of this study, increases in students' understanding of mathematical concepts was reported by teachers, who also noticed students were better both at solving mathematical problems and explaining how they did so to others. Consequently, they also achieved better exam results in mathematics after the use of peer tutoring with manipulatives, as reported by teachers. Active learning environments were established in the schools through the use of manipulatives and peer tutoring together, and teachers recognised that the use of manipulatives with peer tutoring increased the participation of students in their lessons, making them more active learners. These were reflected in the students' results in the Attainment Test. Teachers were also able to manage their time in the classroom more effectively, since the help students were giving each other meant that the teachers needed less actual teaching time to cover the same work.

Teachers' self-confidence improved when they used peer tutoring and manipulatives in teaching mathematics, and they seemed to feel encouraged to develop their teaching skills further. Teachers' attitudes to teaching mathematics were clearly affected very positively by the use of manipulatives and peer tutoring together. These increases were reflected in the students' Attainment Test results and enhanced their engagement in the learning of mathematics.

The use of both peer tutoring and manipulatives together consolidated their effect and enhanced the students' attainment to a greater extent than using each of them separately would have done. Barley et al. (2002) reported that successful peer tutoring in learning mathematics should include the use of materials such as manipulatives. However, they did not examine the differences between the use of manipulatives and peer tutoring both together and separately in an RCT or experimental study. In addition, they did not compare the use of peer tutoring and manipulatives, both separately and together, on learning mathematics. Although they mentioned the use of materials, they were unsure which kind of materials that should be used. Barone and Taylor (1996) in a field study at Fulton Elementary School in Aurora involving 440 mixed ethnicity students, suggested that teachers should be required to prepare manipulatives and train their students to teach each other when they use peer tutoring. Although this study suggested the use of manipulatives with peer tutoring together in learning mathematics, the use of each of them separately has not been examined and compared with the use of each of them separately. The use of both of them together should be compared with the use of each of them separately, as a combination of them can negate their benefits. Although Barley et al. (2002) and Barone and Taylor (1996) suggest that the use of manipulatives with peer tutoring increases the benefits of each, their studies did not examine whether the use of these separately or together is of greater benefit to students. Despite the results of this RCT, the combination of peer tutoring and manipulatives seem to unite their benefits to students' attainment and understanding. Both the quantitative and qualitative results of this RCT support this contention. This is the first experimental study examining the use of peer tutoring and manipulatives, both separately and together, on learning mathematics.

The literature indicates that the more the learning process is structured, the more academic benefits are gained by students. Although the intervention in this RCT took only 12 weeks, the application of the intervention was for only 30 minutes per week, and there were only 24 classes involved in this study; the results showed that students' academic attainment is enhanced by using both peer tutoring and manipulatives. It is recommended that this effect be investigated further in longitudinal studies with a larger sample in order to reinforce the generalisation of the results. In a meta-analysis of 60 studies between 1954 and 1987 involving students from nursery age to college level by Sowell (1989) and in a study by Hartshorn and Boren (1990), the long-term (one year or longer) use of manipulatives was reported to be more effective than their short-term use on students' mathematical attainments. On the other hand, Tymms et al. (2011) carried out a study over two years involving 129 primary schools in Scotland, in which they found that students' attainment in reading and mathematics was positively affected by the use of peer tutoring. Sowell (1989) and Hartshorn and Boren (1990) examined the use of manipulatives alone in the long term, while Tymms et al. (2011) examined the use of peer tutoring alone in the long term. Their results suggest that the use of both peer tutoring and manipulatives separately affected the students' attainment positively.

However, the use of both peer tutoring and manipulatives together over the long term has not been examined.

Education researchers in Saudi Arabia should examine the use of both peer tutoring and manipulatives together to enhance the learning of mathematics in Saudi Arabia. They should consider the use of RCTs and conduct more experimental studies to examine the educational interventions in Saudi Arabia. This research study examines only boys' schools and did not compare these with girls' schools, because of the Saudi culture that separates boys' and girls' schools and offers male researchers only limited access to girls' schools. As conducting such an RCT requires training teachers and observation visits to schools, it is recommended to conduct sharing RCT projects between male and female researchers to compare gender differences.

It is recommended that teachers use learning methods that help to engage the students more in their learning and enhance the value of the learning mediation (Philips & Soltis, 2004; Brophy, 2002). The use of both peer tutoring and manipulatives together has been shown to enhance students' learning of mathematics and the value of the learning mediation. It helps to focus students' communication on the learning subject, which increases the learning value. Therefore, education policy makers in Saudi Arabia should encourage teachers to use such methods to improve their performance in teaching mathematics and improve the mathematics education in the country. They also should support more RCTs and experimental studies being carried out in Saudi Arabia to enhance education.

8.2.2 The effect of using peer tutoring and manipulatives, both separately and together, on students' attitudes towards mathematics

An RCT was conducted to examine whether there was a significant increase in students' positive attitude towards mathematics in the experimental groups compared to the control group. The results of the RCT were analysed using a repeated measures

ANOVA to assess whether there were significant increases in the students' attitude towards mathematics in the post-test compared to the pre-test in each group; then a one-way ANOVA with Bonferroni correction *post hoc* comparisons were used to assess whether there were significant differences in the students' attitudes towards mathematics between the groups. The analysis indicated that there were no significant differences between the attitudes towards mathematics of the students in the experimental groups and those in the control group. The eta squared effect size was small (partial $\acute{\eta}^2 = .014$), which indicates that only 1.4% of the variance is explained by the model in the study population.

The quantitative attitude results of this study do not concur with the qualitative results of this study and the literature, as the use of peer tutoring and manipulatives together were reported to enhance students' attitude towards mathematics. However, there are limitations in the studies examining the effects of using peer tutoring and manipulatives together on the students' attitude towards mathematics. The literature reports that the use of each of them separately enhances the students' attitude towards mathematics.

In an unpublished action research study by Pickett (2011) involving one fourth-grade classroom of twenty students of mixed ethnicity and gender (ten male and ten female) in Hunter Street Elementary School in York, South Carolina, students' attitudes towards mathematics showed statistical improvement after the use of peer tutoring and Pickett (2011) suggested adding the use of manipulatives. However, Pickett's (2011) study has many limitations, one being that this study has no control group and another being that the students involved in the study were not good at multiple choice tests, as reported by Pickett (2011).

However, the literature reports that the use of peer tutoring and manipulatives separately enhances students' attitude towards mathematics. The literature suggests that the use of manipulatives helps to increase students' positive attitudes towards mathematics (NCTM, 2000), and that their excitement about learning mathematical concepts increases during activities involving manipulatives. The long-term use of manipulatives is helpful in a variety of ways, including improving students' attitudes (Hartshorn & Boren, 1990), while Rust (1999) indicates that different styles of teaching can help students to understand mathematics in various ways, and that they enjoy learning when manipulatives are being used.

Heuser (1999), Moch (2001) and Smith et al. (1999) support the view that the use of manipulatives in maths teaching increases students' enjoyment and excitement, which improves their attitude to the subject. Although the results of this RCT show that in the manipulatives group, the pre- to post-test changes in the Attitude Towards Mathematics questionnaire were minimal, the use of manipulatives helped to negate the deterioration in the students' attitude to mathematics.

This study used the RCT research method with a large sample, which avoids bias and enhances confidence in its results. The qualitative part of the study suggests that students' attitudes towards learning mathematics were affected by the use of manipulatives, with an increase in their excitement and enjoyment being reported by both teachers and students involved in the interviews.

The literature and the results of the qualitative data analysis in this short-term RCT (a 12-week programme) agree as to the effect on students' attitudes to maths of using manipulatives; however, the results of the quantitative data analysis do not agree with the literature. The literature suggests that the long-term (one year or more) use of manipulatives is more effective than its use in the short-term. Therefore, it is suggested that the long-term effects on students' attitude of using manipulatives should be investigated.

Roseth et al. (2009) noticed an increase in the energy invested in learning when peer learning was used, which they related to increasingly positive social relationships and raised achievement. The qualitative data in this study show an improvement in the students' attitude towards both the subject itself and its study in the peer tutoring group. The students' excitement, enjoyment, willingness and self-confidence in learning mathematics were all enhanced by peer tutoring, as the results of this study suggest. By evaluating these research results comprehensively, it can be concluded that it was the use of peer tutoring which enhanced the students' attitude to maths, which agrees with the effects described in the literature.

The familiarity with RCTs in studies conducted in Western countries can explain the differences in the results of the students' attitude towards mathematics. This RCT was conducted in elementary schools in Saudi Arabia, where schools, and students in particular, are not used to participating in such studies, and indeed, have never done so previously. Therefore, participants might be somewhat reluctant to give their views in questionnaires, being more comfortable with expressing their feelings orally, therefore, the results were more explicit in the qualitative results than in the quantitative results. The qualitative part of this study gave in details explanation of the students' attitude towards mathematics.

For these reasons, the differences between overall results in this study and the literature can be considered minor. This RCT benefited from combining quantitative and qualitative methods. The improvement in students' communication skills enhanced both their attitude towards learning mathematics and their attainment outcomes, which are related to and affect each other, as Roseth et al. (2009) found.

In conclusion, despite the small eta squared effect size (partial $\acute{\eta}^2 = .014$) which indicates that only 1.4% of the variance is explained by the model in the population, the quantitative part of this study alone cannot explain the real effect of the use of peer tutoring and manipulatives, both separately and together, on the students' attitude towards mathematics. Therefore, the effects of using peer tutoring and manipulatives, both separately and together, on the students' attitudes towards mathematics should be examined in large scale studies over the long term (one year or more) and include collecting qualitative and quantitative data to reach a clearer conclusion. As this RCT examines only male schools in Saudi, studies comparing the effects of using peer tutoring and manipulatives, both separately and together, on male and female students' attitudes towards mathematics should be conducted in Saudi schools to assess whether there are differences between the male and female students' attitudes towards mathematics.

8.2.3 The effect of using peer tutoring and manipulatives, both separately and together, on students' attitudes towards their learning partners

An RCT was conducted to examine whether there were significant increases in the students' positive attitudes towards learning partners in the experimental groups compared to the control group. The results of the RCT were analysed using a repeated measures ANOVA to assess whether there were significant increases in the mathematics attainment from the pre- to the post-test in each group, then a one-way ANOVA with Bonferroni correction *post hoc* comparisons were used to assess whether there were significant differences in the students' attitude towards their learning partners between the groups. The analysis indicated that there were no significant differences between the students' attitudes towards their learning partner in the experimental groups and the control group. The eta squared effect size was small (partial $ή^2 = .009$), which indicates that only 0.9% of the variance is explained by the model in the study population.

The quantitative results of this study are not in agreement with the qualitative results or the literature. The use of peer tutoring and manipulatives together was reported to enhance students' attitudes towards their learning partners. It seems that there is a limitation in the studies examining the effects of using peer tutoring and manipulatives together and the use of peer tutoring alone on the students' attitudes towards their learning partners. There is even more limitation on the literature that examine the use of manipulatives on the students' attitude towards their learning partner.

Pickett (2011), as reported in section 12.2.2, found that students' attitudes towards their learning partners showed statistical improvement after the use of peer tutoring and suggesting adding the use of manipulatives. However, as reported earlier, Pickett's (2011) study has many limitations. The use of peer tutoring alone was reported to enhance students' attitude towards their learning partner. Thurston et al. (2012) reported that the increase in the students' positive attitude towards their learning partner influenced their attainment outcomes.

This current study used the RCT research method with a large sample, which avoids bias and gives strong evidence for its results. The qualitative part of the study suggests that students' attitudes towards learning partner were affected by the use of peer tutoring alone and peer tutoring and manipulatives together. Both students and teachers reported that the relationship between learning partners generally became better and stronger. The literature and the qualitative findings in this short-term RCT (a 12-week programme) agree that the students' attitudes towards their learning partner was enhanced by using peer tutoring and manipulatives together and using peer tutoring alone; however, the quantitative findings do not agree with the literature. In general, there is a limitation in the number of studies discussing the effects of using peer tutoring and manipulatives, both separately and together, on students' attitudes towards their learning partners.

By evaluating the results of this RCT study comprehensively, it can be concluded that it was the use of peer tutoring which enhanced the students' attitudes to their partners, which agrees with the effects described in the literature.

There are many possible explanations for the differences between the quantitative results of this study and both the qualitative results and the literature. One is that students in Saudi are not familiar with expressing their feeling through answering questionnaires. This RCT was conducted in elementary schools in Saudi Arabia, where schools, and students in particular, are not used to participating in such studies, never having done so before. Therefore, participants might be somewhat reluctant to give their views in questionnaires, being more comfortable with expressing their feelings orally. This could explain why the qualitative results were more explicit than the quantitative data in explaining the students' attitude towards their learning partner.

In conclusion, despite the small eta squared effect size (partial $\acute{\eta}^2$ = .009), which indicates that only 0.9% of the variance is explained by the model in the study population, the quantitative part of this present study alone cannot explain the real effect of the use of peer tutoring and manipulatives, both separately and together, on the students' attitudes towards their learning partners. Therefore, the effects of using peer tutoring and manipulatives, both separately and together, on the students' attitudes towards their learning partners should be examined in large-scale studies over the long term (one year or more), which collect qualitative and quantitative data to reach a clearer conclusion. As this RCT examines only the male schools in Saudi, studies comparing the effects of using peer tutoring and manipulatives, both separately and together, on the male and female students' attitudes towards learning partners should be conducted in Saudi schools to assess whether there are differences between male and female students' attitudes in this regard.

8.2.4 The effect of using peer tutoring and manipulatives, both separately and together, on students' social relationships

An RCT was conducted to examine whether there were significant increases in the students' social relationships between the experimental groups and the control group. The results of the RCT were analysed using a repeated measures ANOVA to assess whether there was a significant increase in the students' social relationships from the pre- to the post-test in each group, then a one-way ANOVA with Bonferroni correction *post hoc* comparisons were used to assess whether there were significant differences in the mathematics attainment between the groups. The analysis indicated that all the experimental groups in this study scored more highly in the Sociometric questionnaire than did the control group. The eta squared effect size was large (partial $ή^2$ = .649), which indicates that 64.9% of the variance is explained by the model in the study population.

Students in the peer tutoring group scored significantly higher in the People in Your Class questionnaire than did the students in the control group. Gains were also more significant for the peer tutoring and manipulatives together group than for the control group. Differences were insignificant between the control group and the manipulatives group, while significant gains were observed for the peer tutoring group over the manipulatives group, and the group using both manipulatives and peer tutoring together group over the manipulatives only group. These results are supported by the qualitative data findings both in this study and previous studies, suggesting that both manipulatives and peer tutoring on their own are effective in improving students' social relationships. Although there are only a limited number of studies examining the effect of using both peer tutoring and manipulatives together on students' social relationships, the results of this study support those of studies examining the effects of using both peer tutoring and manipulatives together.

The qualitative part of this RCT is in agreement with the quantitative part, as both teachers and students reported an overall increase in the students' social relationships and their social skills. Both the quantity and the quality of their social relationships were reported to be enhanced after the use of peer tutoring and manipulatives, both separately and together. However, the use of peer tutoring and manipulatives together enhanced the students' social skills and relationships further, as shown by the quantitative and qualitative results in this RCT.

Although some of the literature encourages teachers to benefit from using manipulatives in a social way, no study to date has examined the use of manipulatives with specific reference to social learning methodology, nor has any study on the use of peer tutoring in learning mathematics explored the use of manipulatives combined with peer tutoring. The common factor in the literature is that peer tutoring and manipulatives both help to increase students' communication skills, which increase the value of learning mediation.

This current RCT is the first study to examine the use of peer tutoring and manipulatives, separately and together, in learning mathematics and examining the improvement in social relationships and its impact on students' learning. Although there are a few studies showing that the use of manipulatives affects students' social relationships, manipulatives have been more extensively discussed as cognitive tools that affect students' understanding of mathematical ideas. In this study, manipulatives are discussed as cognitive tools that affect both students' understanding and their social and communication skills.

As regards achievement, the combination of peer tutoring with manipulatives was successful and the students in this group scored significantly higher than students in the groups that used one of these two strategies alone. The literature on the use of peer tutoring argues that its use can work, and the better the peer tutoring is planned, the better are the results achieved.

Regarding students' social relationships, the group using peer tutoring and manipulatives together was significantly different from the control group and manipulatives only group. The joint use of peer tutoring and manipulatives enhanced the students' social relationships more than the use of manipulatives or peer tutoring separately. These results favour the use of peer tutoring and manipulatives together rather than separately to enhance students' social relationships. In general, students who learned using peer tutoring and manipulatives together benefited more in terms of achievement, enhanced social relationships and improved attitudes towards both maths as a subject and their learning partners than did students using only one.

This current RCT stresses that manipulatives must be used socially to gain the full benefit from them. As has already been indicated, the literature only discussed the use of manipulatives as cognitive tools that increased understanding, whereas the results of this study identified manipulatives as cognitive tools that affect not only understanding but also social and communication skills. A number of factors must be incorporated when manipulatives are used in order to obtain the full benefit of their use (Stein & Bovalino, 2001; Clements, 2000; Perry et al., 1999; Moscardini, 2008; Baroody, 1989; Kelly, 2006).

One the other hand, the use of cooperative learning, including peer tutoring, has been reported as enhancing students' social relationships. Johnson and Johnson (1999) affirmed that, as a result of using cooperative learning forms, students exhibited better social relationships with other students. Such learning forms maximise the necessary communication and scientific thinking skills, and help both teachers and students by building a social environment in which students can understand and think constructively. This, in turn, encourages interaction with their teachers and other students and increases the value of learning mediation (Chin & Brown, 2000; Jones & Carter, 1998; Meyer & Woodruff, 1997; Millis, 1995; Resnick & Klopfer, 1989; Wood, 1992).

Peer tutoring can positively affect students' social, communications and behavioural skills (Topping, 2005). Tolmie et al. (2010), in a study involving 24 schools in Scotland, reported an improvement in the students' social relationships when collaborative learning was used. According to Fitz-Gibbon (1988), students who learn by using peer tutoring, whether they are tutoring or being tutored, work well together and communicate effectively with each other.

It can be concluded that the use of peer tutoring and manipulatives, both separately and together, positively affect the quantity and quality of students' social relationships. However, the joint use of peer tutoring and manipulatives enhanced students' social relationship more than the use of either of them alone.

8.2.5 The effect of students' social relationships on their attainments

The regression results of this study showed that insignificant models emerged of the post-test Sociometric questionnaire variables. None of the variables 'Like to work with at maths lessons', 'Like to work with in other lessons', 'Like to share break time with', 'Like to share time outside school with' and 'Like to go to the Masjed with' was a significant predictor of the post-test results of the students in the control group, the manipulatives-only group or the group using peer tutoring and manipulatives together.

However, significant models emerged from the post-test Sociometric questionnaire variables listed above, which were significant predictors of the students' post-test results in the peer tutoring group. These variables were significant predictors in these models, with a positive relationship to the post-test scores of the Attainment test. However, it should be noticed that these variables only explain between 2.4-6.5 % of the study population, which means that these results cannot be generalised on this level.

On the other hand, the results of the regression analysis results of the relationships between the factors emerging from the Attitudes Towards Mathematics Partners questionnaire variables and the post-test results of the students' Attainment Test showed that insignificant models emerged with regard to the former. None of the variables - 'rotated expected working', 'factor ability', 'loading physical fitness', 'behaviour' and 'popularity' - were significant predictors of the post-test results of the students' Attainment Test, in all groups.

The use of peer tutoring with manipulatives, as this study suggested, benefits students in their learning of mathematics in Saudi elementary schools in various ways. The use of peer tutoring is reported to positively affect students academically and socially: academically, it raises students' attainments and increases their mathematical understanding, and socially, it enhances their personal relationships in quantity and quality. According to Johnson and Johnson (1994), there are five main elements that lead to effective group learning, achievement, social, personal and cognitive skills such as problem solving, decision-making and planning - namely positive interdependence, individual accountability, face-to-face interaction, social skills and processing.

A number of studies have indicated a relationship between academic attainment and strengthening friendships, self-esteem and students' attitudes (Eccles et al., 1999; Masten et al., 1995; Parker et al., 1995). In a meta-analysis by Roseth et al. (2006) that comprised 148 studies from 11 countries, indicated that for middle-grade students there is strong relationship between the students' academic attainment and their interpersonal perceptions.

Another meta-analysis, comprising 36 studies on peer-learning in elementary schools by Ginsburgh-Block et al. (2006) indicated that there is positive correlation between students' social relationship and self-concept results with their academic outcomes. Despite the small percentage explained in the regression results in this present RCT, the results of this study are supported by these studies. However, more investigation is required with a larger sample and over a longer period of time in order to present clearer results and withdraw clearer conclusion.

The results of this RCT suggested that education policy-makers, both in Saudi Arabia and worldwide, should be aware of students' social skills and self-development, as well as their academic achievement. This awareness should be transferred to the schools' senior management teams and teachers, in order to provide students with the best learning strategies for building a better society, full of understanding and engagement.

8.2.6 General discussion on the effects of using peer tutoring and manipulatives, both separately and together, on mathematics education

Although some studies assert that the use of manipulatives can ensure positive effects on student learning, others argue that it cannot. Perry et al. (1999) suggest that training mathematics teachers in how to use mathematical manipulatives is necessary. This training should take place at both preparatory level, before teachers begin teaching, such as at teacher training college, and at improvement level, such as in-service training taking place during the teaching career. Mathematics teachers must accept the idea that it is to their students' advantage to use manipulatives as a teaching method. In the same study, although the teachers seemed to be confident in using manipulatives, they agreed that they would appreciate more training in how to use them effectively. The data in this study suggest that teachers should be trained to use manipulatives through a social learning strategy (peer learning), as the result indicated that using such a strategy maximises the positive effects of using manipulatives.

It is clear that the role of teachers is key in terms of achieving the greatest benefit of using manipulatives and peer tutoring, and of how important it is that teachers be aware when they use them. According to Price (2006), teachers are responsible for generating a suitably creative classroom environment. Moscardini (2009), in an observational study that took place in three primary special schools in Scotland, suggests that although students with learning difficulties can achieve meaningful learning when their teachers use materials, teachers should be more aware of the purpose of using these materials and particularly of the way in which they affect their teaching. It is a challenge for teachers to be more aware of their students' mathematical thinking skills, in order to develop suitable teaching environments. Teachers without a strong understanding of the most effective way of using manipulatives might still be in need of support or training in how to use teaching materials and should have a clear idea of the importance of the ways in which they use manipulatives to achieve their aims and facilitate mathematical problem-solving. Students must be actively involved in accumulating knowledge rather than being receptive learners and constructing their knowledge base through others. They build their own meanings (Poplin, 1988) and, as Piaget (1950) believes, build their knowledge step by step by being involved in active learning processes, which aligns with what Philips & Soltis (2004) suggest to be the roles of learners in the learning processes. A number of studies claim there are other steps that should be taken in order to gain such benefits (Moscardini, 2008; Baroody, 1989; Kelly, 2006).

This study stresses that combining the use of peer tutoring with manipulatives is one of the best ways of taking the best advantage of both of them in order to support students academically, socially and in their personal development.

Social constructivism is an approach that explains learning as a social process; that is, learners construct their knowledge socially, learning from each other. In this approach, social activities have valuable roles. Each person involved in social constructivism can simultaneously be both learner and teacher. All learners have individually important roles in the learning process (Philips & Soltis, 2004), students benefit from each other as they learn, and manipulatives work to facilitate this transfer (Berk 1999). This can be observed in both student and teaching roles in the classroom, in line with the social constructivism theory. The teacher's role is to prepare the learning environment for lessons, such as by arranging the overall layout and classroom materials, and to manage the classroom discussions. Frobisher (1999) identified a number of manipulatives that can be used to introduce and explain mathematical ideas and concepts. These manipulatives can help teachers to build a social environment of which students can take advantage to share their knowledge and experiences.

The qualitative part of this study yielded a number of interesting results during the interviews with both teachers and students' interviews, showing that interventions had positive effects on the teachers' performance and their social relationships with their students and with other teachers. These effects on teachers were reflected in their students' academic performance and social relationships. The researcher noticed that students spoke of improvements in their social relationships with teachers and they were happy with these improvements. Teachers can work on their ability to improve their relationships with students to enhance their students' academic performance and to build an active and social learning environment that enhances their students learning and social lives. Researchers and education policy makers could consider the results of this study and support and apply more RCTs in

Saudi Arabia to explore and develop interventions that assist in improving learning in Saudi Arabia.

8.3 Review and critique of the methodology

As explained in the methodology section of the pilot study chapter (Chapter 4) and in the methodology chapter for the main study (Chapter 5), this research aims to develop, pilot, test and research the effectiveness of using peer tutoring and manipulatives, both separately and together, in learning mathematics to improve the mathematics education in schools in Saudi Arabia. The pedagogies explored include the use of manipulatives and peer learning. The thesis reports investigations using a factor design to explore the effects of incorporating resource-led and peer learning into teacher pedagogies. For this, four elements were measured: students' attainment; students' attitudes towards mathematics; students' attitudes towards their learning partners, and; students' social relationships.

This study used an RCT as its research methodology. There were three experimental groups and one control group. Teachers assigned to the first experimental group used the manipulatives to support their teaching strategy, those assigned to the second used peer tutoring only, and those assigned to the third used both manipulatives and peer tutoring together. The control group used the normal method of teaching - effectively, 'treatment as usual'.

The RCT is generally considered to be the gold standard research method for evaluating interventions in many fields (Sullivan, 2011). This current RCT was conducted to the highest standard that the researcher was capable of; however, it is difficult to control all possibilities in any research in evaluating an experiment that involves a group or groups of people. An RCT has many strong aspects, and it can provide evidence that is widely accepted however, there are further limitations need to be discussed.

In this RCT, there was a small number of students who did not complete the post-test on some of the study instruments as they were absent on the day that these tests were conducted. Despite the many efforts that the researcher made to test these students, there remained some students who were not post-tested. The limited time that the researcher had at the end of the field work trip, and the field work having been carried out at the end of the school term limited the opportunities of re-testing these students and therefore the researcher had to stop the testing. However, only a small number of students did not complete the post-test; however, this did not exceed 5% in any condition and therefore did not significantly affect the validity of the RCT in this study.

As this was the first RCT conducted in Saudi Arabia and one of only a limited number of experimental studies to be carried out, the researcher faced a number of management issues. However, the developmental study (pilot study) was a very important phase that allowed the researcher to become aware of these difficulties in order to overcome them when carrying out the main study. The researcher learned more about the departments in the Ministry of Education in Saudi Arabia who are responsible for working with researchers who wish to undertake research in the Saudi schools, and this saved time in the main study. The processes that the researcher had to go through in order to be able to conduct the research in Saudi Arabia became clearer after the development study and therefore, many of the management issues were avoided at the time of the main study.

Dealing with teachers who have not previously been involved with researchers who come to suggest changing the way of teaching that they have used for many years and asking a number of them to move out of their comfort zone was not an easy task. However, the researcher was able to build good relationships with teachers through the meetings and encouraged them to participate in changing their performances and the learning of mathematics in Saudi Arabia. After the meetings, teachers were encouraged and enthusiastic about being part of these interventions. In addition, the researcher was available to answer any phone calls and emails from teachers asking for some details about the interventions. Intensive observational visits were made by the researcher in the first two week to the classes to ensure the correct implementation of the interventions in the classes followed by face-to-face meetings with the teachers to discuss any comments and answer any questions. Although these processes were very difficult, they were very important to ensure that the interventions were carried out to the highest possible standard. Although it is clear from the study findings that the teachers did their best and attempted to respect the researcher's requirements, it was not possible to be entirely certain of the implementation of the interventions in his absence.

Two units of the fourth year mathematics curriculum were chosen for the experiment, each of which needed five weeks of teaching. The first unit involved fractions, and the second decimals. These units are clearly related to each other. In the development study (pilot study), eight classes were chosen to represent the study population, while in the second (main) study, 24 classes were chosen. All the teachers who volunteered to take part received the required training, so they were very clear about the learning strategies to be used in their teaching. Each class was provided with a 12-week programme pack, developed to guide the teachers, who were asked to use the programme at least once a week for 30 minutes. The school senior management teams and classroom teachers equalised the common factors to the best of their ability under the supervision of the researcher. All students participating in the study were administered the study instruments twice, once before the treatment and once after it. In addition, all the teachers from the experimental groups and students from the experimental groups were interviewed to establish their views on using peer tutoring and manipulatives, both separately and together, on mathematics education in Saudi Arabia.

The pack provided to the teachers was very important as it had much important information that the teachers might need which saved the researcher time answering many questions that might need clarification for the teachers. In the development study, the researcher was able to obtain some more needed information and details had to be included in the main study pack. This information saved the researcher time during the main study and gave him the opportunity to deal with more important issues.

Both Topping et al. (2011), whose study involved 86 co-educational and mixed-ability Scottish primary schools and Tymms et al. (2011) who studied 129 primary schools, conducted an RCT study over two years. Tymms et al. (2011) reported that peer tutoring is positively effective when it is applied for 30 minutes per day, five days per week, while Greenwood et al. (1992) used higher levels of ‘‘intensity’’ of a class-wide peer tutoring programme over 19 weeks, which increased positive spelling outcomes. However, according to Fuchs et al. (1997), levels of intensity of intervention often differ between studies. Fuchs, Compton, Fuchs, Bryant, and Davis, (2008) conducted an intensive intervention over 16 weeks, applying it for 20-30 minutes three times per week. The literature differs regarding the best timing application of education interventions. An intervention of 30 minutes once per week for 12 weeks was long enough to detect its effectiveness on the students' attainment and their social relationships; however, the small eta effect size of the students' attitude towards mathematics and their attitudes towards their learning partners implies that the changes in students' attitudes cannot be detected in this short-term intervention. The researcher had to curtail the interventions for reasons such as the funds available from his sponsor covering only three months for the work field trip and that the units that were chosen to be covered needing 12 weeks teaching. Therefore, it is recommended to conduct longer interventions to discover the effects of using peer tutoring and manipulatives, both separately and together, on students' attitudes towards mathematics and on their attitudes towards their learning partners.

The process of applying the different interventions and the fidelity of their implementation in this RCT were ensured through observational visits that the researcher made throughout the study. However, the researcher was not able to attend each class of the interventions, which might leave a question about the fidelity of the implementation. Although the results of both quantitative and qualitative parts of this study and the observational visits, some of which were made without informing the teachers of them, provide evidence that the teachers did their best in applying the intervention, it would have been ideal if the researcher has been able to be more sure of the fidelity of the implementation of the interventions through other methods.

Given that this RCT involved one control group and three experimental groups, four instruments were applied to evaluate mathematics education and the effects of the intervention. Each instrument was applied twice, once before the interventions and once after them; therefore, all the related data were analysed to test the study hypotheses and assumptions. Descriptive statistical means, standard deviations and changes pre- to post-test were computed for each group. Analytical tests, including repeated measure ANOVA within condition analysis of significance to discover if there are significant changes between the pre- and the post-test scores in each condition in all study instruments, and one-way ANOVA with Bonferroni *post hoc*, were applied to examine the significant differences between the groups in all the study instruments. Further regression analysis was undertaken to discover whether the five keys factors that emerged from the Sociometric questionnaire, and the six key factors that emerged from the Attitude Towards Mathematics Partner questionnaire predicted the students' attainment scores. These were computed using the SPSS for Windows programme, and the data from the interviews underwent thematic review analysis.

The researcher ensured that appropriate methods of analysing the quantitative data in this study were used. The repeated measures ANOVA is a valid test to evaluate measurements that are repeated over time (e.g. pre- and post-test) when there are more than two groups. It is used to show the interaction between the different groups from the pre- to the post-test and give overall results that reduce the error size. The one-way, between-subjects ANOVA with Bonferroni correction *post hoc* is a valid method that can be used to compare the differences between groups and help to negate the problem of multiple comparisons. Bonferroni correction is considered the simplest and most conservative method that can control the family-wise error rate.

Although conducting an RCT in education research is, generally speaking, unusual, developed countries have established and funded the gathering of evidence based on education data in order to enhance the education in their countries. In 2002, the Department of Education's Institute of Education Sciences in the USA established the What Works Clearinghouse (WWC). It was established to evaluate and provide evidence on the effectiveness of education interventions. The evidence provided by WWC is important to enhance the education in the USA (Clearinghouse, 2008). "The mission of the WWC is to be a central and trusted source of scientific evidence for what works in education" (Clearinghouse, 2008, p.1). In the UK, the Education Endowment Foundation (EEF) was established as "an independent grant-making charity dedicated to breaking the link between family income and educational achievement, ensuring that children from all backgrounds can fulfil their potential and make the most of their talents" (Rutt et al., 2014. P. 2). In addition to the EEF in the UK, "The Campbell Collaboration is an international network that supports the preparation and dissemination of high quality systematic reviews of research evidence on the effectiveness of social programs, policies, and practices" (Noonan & Eamonn, 2014, p. 3). RCTs are considered to be strong evidence by the WWC, the EEF and The Campbell Collaboration when they are designed and implemented well. However, RCTs in education studies have not previously been used in elementary schools in Saudi Arabia. There are many challenges that might prevent the researcher in Saudi Arabia from conducting RCTs. First, they can be costly and the cost must be covered by an institution that believes in the need for such study results. Researchers need to travel between schools and print many papers, both of which can be expensive. Preparing and conducting RCTs can be time consuming, and requires such management skills as time management and negotiating with the education authority, school heads and senior staff, teachers and students. Timing is very important in an RCT since nothing can be repeated. Everything must be meticulously planned and carried out on schedule - the administrative paperwork, sampling, the pre- and post-tests, the learning strategy implication and the interviews. If just one element were missed, the whole study would be affected. One difficulty that researchers might face when considering an RCT is the complex research design, since RCTs require a combination of different methodologies including quantitative and qualitative methods. An RCT that aims to examine interventions requires the organisation and running of training courses for the teachers who will be applying those interventions in the classroom. Furthermore, the researcher should ensure sufficient classroom observation time during the RCT to ensure the correct implementation of the interventions. Despite all these critical issues that can make undertaking an RCT very difficult to manage in Saudi, PhD students and researchers should be encouraged to undertake such studies, since there are also many advantages in doing so in the Saudi context at elementary level, particularly for PhD students.

Although the idea of carrying out RCTs in Saudi schools seemed to be unfamiliar, the Education Authority, senior management teams, classroom teachers, and students involved in this RCT study were all highly cooperative and passionately involved, doing their utmost to be effective participants. They deeply respected the RCT and enjoyed being involved in the research. Even after the field-work was completed, teachers are still in touch to ask about the learning strategies and they were very eager to know the research results. All the participants in this study were open-minded in sharing their opinions and were not embarrassed to ask about the teaching processes and anything else they wanted to know. These positive points are reasons to encourage more researchers to undertake this type of study, in order to provide the Saudi education authorities with strong evidence that can positively enhance the country's education.

In this researcher's opinion, the Saudi education authorities will receive the results of this study with respect, and will be happy to train teachers to apply the manipulatives and peer tutoring together learning strategy in Saudi schools. They will be eager to support more RCTs to be undertaken not only in Saudi Arabian elementary schools but also at other education levels, in order to gather more evidence of its benefits for Saudi students in different age groups. They may be willing to support the creation of teams to carry out more RCTs, in order to improve learning in the schools. The effect size of the experimental groups in this study was high, which means that the sample size required in such studies is reasonable and manageable, although it is difficult for PhD students to manage RCTs which require a large sample size in order to reach a high effect size. The results of this research highlight a need to improve both the teaching and learning of mathematics in elementary schools; however, although there were real weaknesses in the pre-test scores, the students' improvement after the interventions was very high.

The control group, which received no treatment in this study, showed lower performances in all the study instruments, indicating that elementary school level would be an ideal choice for further RCTs and a productive environment for research that could provide obvious effects and results. Elementary schools provide the first and most basic level of education and affect all future levels; therefore effective research at this level is very important and can make a difference for future generations.

8.4 Implications of the study

This RCT study examined the effect of using peer tutoring and manipulatives, both separately and together, on the learning of mathematics in elementary schools in AlAhsa city in Saudi Arabia. It aimed to represent an effective method for learning mathematics using peer tutoring on its own, manipulatives on their own, or both peer tutoring and manipulatives together. The effect of using peer tutoring and manipulatives, both separately and together, on students' achievement, their attitudes towards learning mathematics and their learning partners and their social relationships was examined, together with the effect of students' social relationships on predicting their achievement in mathematics. An RCT may yield highly reliable evidence that can be accepted as authoritative by policy makers; therefore, it is expected that this study will be important to the Saudi Ministry of Education, which is responsible for education policy in Saudi Arabia. A number of projects were supported by the Saudi government in order to progress education particularly in mathematics, and this study aims to help the Saudi education authority with this.

The Saudi government spends a substantial amount of time and money - approximately one third of the kingdom's annual budget - on the public education sector, which it considers to be of paramount importance; and has established a number of projects over the years to improve it at all levels. Students start school at the age of six, and continue for 12 years (six years at elementary level, three years at middle level, and three years at secondary level). Elementary schools are considered to be the most important level of public education in Saudi Arabia, and the government treats this sector with great care as it is considered to be the foundation on which all future learning is built.

Before 1957 there were no universities in Saudi Arabia, so the best school students were recruited and trained to teach those in the school range below them. In 1953, the Saudi government established the middle teachers' institutions, to train carefully selected former elementary school students who were now in middle schools to become teachers in elementary schools. In 1965, the middle teachers' institutions became secondary teachers' institutions, training carefully selected former middle school students who were now in secondary education to become teachers in middle schools. In 1976, the secondary teachers' institutions became middle colleges, which were established to train carefully selected former secondary school students to become teachers in secondary schools. In 1988, teacher training colleges were established, with graduate level curricula which aimed to qualify their students to become elementary level teachers of various subjects. All the middle and secondary teachers' institutions, the middle colleges and the teacher training colleges were run by the Ministry of Education. In 2007, responsibility for running the teacher training colleges was transferred to the Ministry of Higher Education, which decided that responsibility for each college should be transferred to the nearest university. This was just one of the efforts made by the Saudi government to develop education in elementary level schools.

The Ministry of Education concentrated on developing curricula and school buildings, and training teachers in response to the need to develop education in the kingdom.

In 2007, the government established the King Abdullah Project for the Development of Public Education, with a budget of US$3.1 billion (*Asharq Al-Awsat*, 2007). According to the project website, its aim is to meet the challenges resulting from the need for the new skills demanded by information and communication technology and globalisation, which are faced by public education in Saudi Arabia.

These challenges encouraged the Saudi government to start thinking about the need to develop and improve the education system. The project established a fresh vision for a new system focusing on teachers, students, schools, districts and Ministry of Education rules.

Asharq Al-Awsat newspaper (2007) reminded the project committee chairman of the importance of promoting and incorporating worldwide experience into the process of developing education in Saudi Arabia. Observational educational visits by representatives of the Saudi education authorities were organised to the United States, United Kingdom, Ireland, Austria, Switzerland, Canada, France, New Zealand, Malaysia, Singapore, Korea, China and Japan in order to benefit from their success and experience.

There are four major macro-strategies on which this project will focus. The first is '*creating a model for change',* including the improvement of teacher's teaching, students' learning, and school's funding and organisation. The second is '*building capacity and capability for change*', which includes supplying the needed funds, information and skills in order to help those involved to play their parts efficiently. For example, the capability includes collecting data on teachers' training needs and the areas of education that need to be developed. The third is '*sustaining change* *through effective institutions and policies*', including support for effective organisations and government departments that can, in turn, support the project. The fourth is '*managing and communicating change',* focusing on management and communication for all those involved. In order to apply these macro-strategies, the ten following strategic objectives have been established:

1. Empower districts and schools to manage and lead change.
2. Improve the curriculum, instruction and assessment to promote student success.
3. Provide equitable learning opportunities and support systems for all students.
4. Provide early childhood education for all.
5. Provide a world class environment conducive to student learning.
6. Promote student health, character, discipline and welfare.
7. Engage families and community partners to support a culture of learning.
8. Develop a system to professionalise the teaching practice.
9. Leverage technology to improve performance.
10. Improve governance, leadership, and policy to sustain change. (p. 11-12).

The following outcomes should be achieved by the end of the project:

1- Improved access to quality early childhood education.
2- Improved student understanding of Islamic values, principles and culture.
3- Improved performance in science, technology, engineering and maths.
4- Improved reading, writing and oral communication skills in Arabic.
5- Improved reading, writing and oral communication skills in English.
6- Demonstrated 21st century skills, such as problem-solving and critical thinking.
7- Increased readiness for life, citizenship, academia and the labour market.
8- Increased student health and discipline.

9- Improved equality of access to quality learning opportunities for all, including for students with special needs, the gifted and talented, and at-risk students.

10- Improved retention and graduation from high school. (p. 12).

Although the project showed great promise, and both the project and the expected outcomes are well set out, a number of issues must be discussed in relation to it. The project claims to be modelled on studies conducted in other countries, so there is a need to examine every change in the policy to assess whether it depends on national rather than international studies, since what might work in other contexts does not guarantee success in a Saudi context. The project budget is very high, which offers the opportunity to fund research studies at policy level and support researchers in the field. This study introduces a research method that can work in the Saudi context, and yield results of the highest order that should be scrutinised and then accepted for the introduction of new practice in education. RCTs would be very helpful in examining the outcomes of this project; as the results of this study showed, the Saudi context is a productive environment in which to apply them. Moreover, RCTs seem to be helpful to the education policies makers in Saudi Arabia to examine new interventions they can suggest to their teachers in various subjects at all levels.

Undertaking RCTs requires the use of various methodologies, including quantitative and qualitative (Connolly, 2008), and their results give broad explanations of the study problems which, in their turn, help educational policy makers to understand the issues raised by the research. This research introduces an effective teaching method that is helpful for mathematics teachers to use in the classroom.

The use of peer tutoring and manipulatives, separately or together, is effective in various ways. It affects students' attainment, social relationships and their attitudes to maths and their learning partners, and educational policy makers in Saudi may use the results of this research study to present this method to their teachers and train them to benefit from it. According to the project committee chairman, a number of international visits were organised to benefit from other countries' successes. Although such visits can be important for understanding the cause of these successes, they did not mention the importance of analysing the research studies published in these countries, of undertaking the same research studies in Saudi Arabia in order to understand the real issues and challenges affecting education in Saudi and the best ways of resolving these issues. Tymms et al. (2011) suggested that the use of RCTs can be helpful in creating and developing education policy at a high level.

Despite assurances that the expected outcomes of the King Abdullah Project would be examined, the criteria that will be used to assess it have still not yet been established: and although it began in 2007, by 2014, at the time of writing, the results of this study have still not been published. Did the project work well or did it not? Again, it is recommended that RCTs, the results of which are acceptable at policy level, should be used here.

This researcher's results also revealed substantial weaknesses in teacher training and teaching. The teachers who participated in this study received their training in the interventions with passion, and their application of the learning styles were reflected in the students' results. The impression was formed during the study that there is a lack of training for mathematics teachers in methods that would help them to improve and develop ways of maximising their students' role in learning. There seem to be weaknesses in teacher training in the use of pedagogies, reflected in the results of the students in the control group, and the teachers seem to be unaware of active learning strategies.

The result of this research shows that the use of peer tutoring with manipulatives helped teachers to help their students to maximise the latters' role in learning and increase their communication skills, thus enhancing the value of learning mediation, which, in turn, increased and improved their social skills, attainment, understanding, self-confidence, and social relationships. Involving teachers in RCTs, and allowing them to be involved in interventions, can fulfil many of the criteria in their training: the direct training they would receive before undertaking the interventions, the developing climate in which they are involved and the sharing of experiences.

In addition, RCT research offers teachers training in new interventions that have been largely successful in other countries. They can share such methods with other teachers, creating a social learning environment between themselves in which to share effective teaching methodology. During the interviews, teachers agreed that they were happy to share with others the method they used during the intervention, and they trained other teachers to use it.

The pedagogy that was used in this research study is the most rigorously tested pedagogy in Saudi Arabia and was scrutinised by one of the most trusted methods worldwide. Teachers can use it, safe in the knowledge that it works. The Saudi education ministers are responsible for running schools and training mathematics teachers, and this study can help the teacher trainers at Saudi education institutions to offer a successful learning style to mathematics teachers who, with their students, can then take advantage of it. The students, for whose benefit this research is ultimately undertaken, are the most important factors in the learning process and those most likely to profit by it. The King Abdullah Project argues that students' learning should improve greatly through using the project. However, the results of this study highlight that students' learning in mathematics is very weak and there are substantial deficiencies in their learning and communication skills, although developing these skills is vitally important in the 21st century.

The control group in this study showed weaknesses in their academic and social skills, but this research provides the Saudi education policy makers, teachers, and education authorities with reliable information that explains the current state of affairs in mathematical education in Saudi Arabia. This information may help them to improve Saudi mathematical education by introducing a method that improves students' learning by increasing their communication skills. These, in turn, raise their mathematical achievement, deepen their understanding, and improve the affective skills that develop their social relationships and self-confidence.

RCTs help to identify and analyse the issues involved in students' learning, recommend and trial possible solutions and introduce and examine interventions that offer students new methods of learning to help them maximise their role in learning. The value of manipulatives and peer tutoring in improving the quality of their learning is demonstrated by these research results.

Given the reliability of the results of this research, education faculties in the Saudi universities responsible for training mathematics graduates to be teachers can also benefit by using them to provide their students with effective new strategies, not currently in use in Saudi Arabia, with which to maximise the value of their future teaching. Research centres and educational faculties can also confidently apply them to their research studies. The effect size in this research study is very high, meaning that conducting RCTs in Saudi educational studies require a smaller sample size than those required in other countries, which saves researchers effort and expense.

The results also demonstrate the need to conduct RCTs in Saudi Arabia, to investigate the issues, resolve them and propose learning strategies.

This study indicates that the use of peer tutoring combined with the use of manipulatives affected both the students' achievement in mathematics and their social life in very positive ways, and it can therefore directly assist in building a better society.

8.5 Recommendations

There is a lack of research on education in Saudi Arabia, particularly in the publicly-funded schools sector. Education policy makers, researchers, universities, teachers and other education bodies have little research from the public sector to draw on. Even large-budget projects did not consider using RCTs as a method of collecting information on, and analysing the current state of education in Saudi. Neither did they consider RCTs as a method of suggesting new pedagogies or ways of running schools.

The RCT as a research method is not used in these studies, although it is considered to be one of the strongest methods in educational research, and this present study suggests that Saudi Arabia is a productive environment in which to run RCTs. In this present study, the use of peer tutoring with manipulatives was found to affect students' learning of mathematics very positively, in various ways. Therefore, it is generally recommended that RCTs, and the use of peer tutoring and manipulatives in learning mathematics, should be given high priority in future educational research in Saudi Arabia. The recommendations drawn from this current study for government education policy makers, further education researchers, teachers, and teacher educators in Saudi Arabia will be discussed.

8.5.1 Government

The Saudi government appears to be concerned with improving public education, and is making extensive efforts and spending huge amounts of money in order to improve education. However, teaching standards in Saudi still require significant improvement, and student outcomes have still not reached government expectations. A number of education experts argue that, generally speaking, teaching was better in the past than it is currently. The education budget should be spent judiciously and research into how to raise education standards should not be neglected. Indeed, expenditure on research studies has been shown to be beneficial worldwide, and if the results of such studies are disseminated internationally, this is one of the best ways of sharing trusted, valuable information.

In this light, it is recommended that the Saudi government establish a centre for research on learning and teaching. Such centres have already been established in a number of countries around the world, particularly in developed countries such as the USA and the UK. The research carried out in such a centre could be of considerable benefit to researchers, teachers, teacher educators, and hence, to the overall Saudi education system. In addition, the US Department of Education has established a database which collates, reviews and makes available online, reliable research containing evidence on the effectiveness of educational practices, programmes and policies. The aim of this database, known as the What Works Clearinghouse, is to inform researchers, educators, and policy-makers in their efforts to improve students' education. It is recommended that the Saudi government establish a similar database to gather evidence from research as to what works in education in Saudi Arabia.

It is suggested that education policy makers use the research methodology of this current study to collect information on the current state of education in Saudi Arabia. The policy makers may also use this methodology to examine current teaching and learning strategies and explore the suggested teaching and learning strategies they wish to be applied in schools. Applying RCTs in Saudi appears to be a promising method of research, offering trustworthy results that can only improve education at policy level. As the King Abdullah Project for developing publicly-funded education is still in progress, it is not too late to start conducting research studies to evaluate this and other projects currently in progress. Such evaluation could ascertain what has been done in the projects so far and examine ideas that have been encountered in other countries to assess whether they would work in the Saudi context.

The results of this present study showed that the use of peer tutoring with manipulatives improved the mathematical education of fourth grade elementary students in AlAhsa city in Saudi Arabia. Although the results of RCTs are accepted at policy level, the results of this current study cannot be generalised from the population of the study. Hence, the researcher recommends that education policy makers in Saudi Arabia initiate further studies on the effects of using peer tutoring, with or without manipulatives, in mathematics and other subjects. These studies should be undertaken with students at different levels of education in the public sector.

In addition, the results of this present research showed that the students' communication and affective skills increased with the use of peer tutoring and manipulatives, and that students' attainment levels were predicted by their social relationships with the use of peer tutoring alone. Therefore, it is important for educational policy makers to examine different areas that might affect students' learning, with particular regard to the social and metacognitive effects. This research should be undertaken in various cities and districts in order to gather as much information as possible on the use of peer tutoring and manipulatives. The more studies that can be carried out in this field, the more information can be gathered and correlated.

This present study focused on one of the most important elements in the learning process, namely, the students. However, more detailed work might be done on the effects of using peer tutoring with or without manipulatives on other factors, such as teachers and schools, and these also need to be included in research. The government of Saudi Arabia should make more effort to focus on such education research as the basis of their education development, and in order to be able to suggest valid, workable and effective techniques to both teachers and students. Expending more effort and money on such research can be highly productive, and publishing results worldwide would both demonstrate their commitment and provide the national and international community with fresh information on state education in Saudi Arabia.

8.5.2 Researchers

There is a dearth of sound education research in Saudi Arabia, including that examining the current state of and future vision for education. This is evident in the scarcity of published studies of publicly-funded schools in Saudi Arabia, Indeed, there is lack of research on and evaluation of large-scale projects such as the King Abdullah Project, that are already in progress.

This research study is therefore a call for educational researchers to engage in RCT research studies. The advantages of doing so in the Saudi context are obvious, as this research study has already suggested. Scrutinising learning interventions is a critical factor in educational research in Saudi, since such research provides trustworthy results that are accepted at policy level and avoid any bias in sampling, thereby enhancing their validity.

Regarding sampling, although the sample size of this present study was appropriate for its purpose, a similar study might be undertaken covering the whole district, which would provide even stronger evidence to researchers interested in Saudi education. In addition, work could also be done with elementary students in various years and at other school levels, such as high schools and in various cities throughout Saudi Arabia. Although this study examined a number of different variables (students' attainments in mathematics, attitudes towards mathematics, attitudes towards their learning partners and social relationships), other variables, such as students' critical thinking and metacognition skills, could be considered in other studies.

This study concludes that the use of peer tutoring and manipulatives can positively affect students' learning of mathematics. Conducting more RCTs in Saudi Arabia and researching further into the application of new teaching and learning interventions can enrich Saudi research communities by providing them with valid information based on trustworthy research methods. This researcher conducted a RCT in order to measure the effectiveness of using peer tutoring and manipulatives, both separately and together, on mathematics education in Saudi elementary schools. The fact of conducting it *per se* showed that RCTs in a Saudi context are entirely realistic and practicable, and the results in this case were very promising.

The Saudi schools' senior management teams, classroom teachers and students were very cooperative with the researcher, showing great willingness to participate; it is therefore suggested that researchers should conduct studies into the effectiveness of applying RCTs in Saudi Arabia. The use of peer tutoring as a social learning technique, combined with the use of manipulatives, showed promising results in this study in many aspects of learning. It would therefore be worthwhile conducting research into combining the use of manipulatives with other social learning techniques such as cooperative learning, as these techniques produced good results, as recorded in the literature and discussed in Chapter Two.

Further, it is recommended that more studies be conducted to evaluate the current state of teaching in Saudi Arabia and to collect as much information as possible on teachers' areas of weakness so as to understand the issues they need to work on in order to develop their pedagogies.

8.5.3 Teachers

The role of teachers in education is paramount. Teachers should search for new and effective teaching methods and pedagogies that enhance their students' learning and improve their quality of life. Classroom environments should be active and should encourage discussion throughout the learning process. Students should build their own knowledge through discourse and exchange of experiences. The teacher's role is to create the learning environment and manage classroom discussions (Brophy, 2002).

The role of the educator in social constructivism is to facilitate and assist students during the learning processes, not simply to transfer mathematical knowledge to them (Irvin, 2008). The role of social constructivist teachers is to encourage learning in the classroom through, essentially, investigation (Beck & Kosnik, 2006). The results of this research study – namely, that the use of peer tutoring and manipulatives in teaching mathematics is proven to be an effective teaching methodology - offer mathematics teachers a pedagogy tested in the Saudi context. The results of this research showed that Saudi teachers are using ineffective pedagogies, but in order for them to improve, they need to be familiar with educational research that has examined and evaluated effective teaching methods. They should implement knowledge based on educational theories and research studies to improve their teaching performance and to make their classes more effective and attractive. They should be open-minded to the new pedagogical knowledge related to their subjects, as recommendations based on research studies can be updated and improved upon over time. Teachers should also engage in evaluating current and new pedagogies, and try different teaching methods until they find one appropriate to them which will enhance both their own performance and their students' learning.

Teachers' involvement in research, particularly in implementing interventions, can be one of the best ways of improving their own performances and they should be more proactive in exchanging and sharing teaching experiences. To do this they need to familiarise themselves with, and fully understand, the most effective ways in which to improve their students' learning.

8.5.4 Teacher educators

Researchers, education policy makers and education authorities must all work together to help teachers improve their pedagogies by providing them with up-to-date information and training.

In terms of teacher training and professional development, it is recommended that teacher educators offer teachers training on how to develop the role of student, in self-development and on becoming reflective teachers. Further, teachers should receive training on how they can benefit from research studies and from co-operation with researchers. To this end, teacher educators should provide teachers with up-to-date and reliable research studies in teaching and learning, including websites and journals containing complete studies or extracts from them. Bearing in mind that the English language skills of many Saudi teachers are poor, useful studies, summaries and extracts should be made available to them in Arabic translations.

It is also important that teachers should receive training in the application of interventions, such as training in how to use manipulatives effectively, as well as in the use of social learning approaches such as peer tutoring and cooperative learning. Further, researchers and trainers could be invited from other countries, in particular the more developed countries, in order that the Saudi teacher educators can benefit from their experience in training teachers. Moreover, the results of this study suggest that, as a policy, mathematics teachers should be encouraged to use peer tutoring with manipulatives as a teaching method, given its proven positive effects in a number of ways on students' learning.

Through formal and informal conversations with teachers, the researcher gained the impression that teachers are in need of motivation to become involved in training programmes. A number of teachers suggested that they did not perceive any benefit to attending a training programme. Therefore, it is suggested that teacher educators should think about ways of motivating teachers, such as by making them more aware of the benefits they stand to gain by attending training courses.

In summary, the results of this study indicate that teachers should significantly improve their teaching in order to improve their students' learning; the government should make more effort to research, evaluate and improve current standards of teaching, which is at the heart of education; and the government should also establish, examine and offer effective teaching pedagogies to help teachers improve their own methods. The RCT seems to be one of the best research models in the education field.

The journey through this thesis has made the researcher aware of the importance of making changes to the teaching methods in Saudi Arabia and moving from the use of traditional teaching methods to more modern methods, such as peer tutoring and manipulatives. By doing this, teachers will move from their comfort zone and make more effort to make their teaching more exciting, motivating and interesting to their students. Thus, students will in turn move from being mere passive recipients of learning to being active participants and the centre of the learning process.

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Appendices

Appendix 1

The final version of the Attainment Test

<u>الاختبار التحصيلي</u>

عزيزي الطالب:

يهدف هذا الاختبار لقياس التحصيل القياسي لمقرر الرياضيات في وحدتي الكسور و الأعداد العشرية.

لن يؤثر أداءك للإختبار على درجاتك في المادة و لن يدخل في أي تقييم داخل المدرسة.

أجب عن جميع الأسئلة خلف الورقة في نفس الورقة ، اتخدم ورقة خارجية لو أحببت كمسوده.

قبل البداية الرجاء تعبئة الخانات التالية:

الاسم	
تاريخ الميلاد	
اسم المدرسة	
الصف و الفصل	
اسم شريكك في تعلم الرياضيات	

شكراً لك على تعاونك.

فِي التَّمْرِينَيْنِ ١ وَ ٢، ضَعْ إشارَةَ (✓) أمامَ العِبارَةِ الصَّحيحَةِ وَإشارَةَ × أمامَ العِبارَةِ غَيْرِ الصَّحيحَةِ

فِي الكَسْرِ غَيْرِ الفعلِيِّ، يَكونُ البَسْطُ أَصْغَرَ مِنَ المَقام.

لإيجادِ كَسْرٍ مُكافِئٍ لِكَسْرٍ ما، نَضْرِبُ كُلاً مِنَ البَسْطِ وَالمَقامِ فِي العَدَدِ نَفْسِهِ أَوْ نَقْسِمُهُما عَلَى العَدَدِ نَفْسِهِ.

قارِنْ بَيْنَ كُلِّ عَدَدَيْنِ فيما يَأتي، بِاسْتِعْمالِ > ، < ، =:

١,٧٥ ⬤ $١\frac{٣}{٤}$ ‏ ‏ ‏ ٣,٢ ⬤ $٣\frac{٢}{١٠٠}$

اختيارٌ مِن مُتعَدِّدٍ: أيُّ الْجُمَلِ التَّالِيَةِ غَيْرُ صَحيحٍ؟

أ) $\frac{١}{٤}$ = ٠,٢٥ ‏ ‏ ‏ جـ) $\frac{١}{٤}$ = ١,٢

ب) $\frac{٦}{٨}$ = ٠,٧٥ ‏ ‏ ‏ د) ٠,٢٠ = ٠,٢

أَوْجِدْ كَسْرًا مُكافِئًا لِكُلِّ كَسْرٍ مِنَ الكُسورِ الآتِيَةِ:

$\frac{١}{٥}$

$\frac{٣}{١٢}$

أُكْتُبِ الْكَسْرَ الاعتياديَّ وَالْكَسْرَ الْعَشْرِيَّ الذي يُمثِّلُهُ الجزءُ المُظلَّلُ:

اختيارٌ مِن مُتعَدِّدٍ: مَا الكَسْرُ الَّذي لا يُكافِئُ المِنْطَقَةَ المُظَلَّلَةَ مِنَ الدّائِرَةِ؟

أ) $\frac{١}{٢}$ ‏ ‏ ‏ جـ) $\frac{٤}{٨}$

ب) $\frac{٢}{٤}$ ‏ ‏ ‏ د) $\frac{٧}{١٢}$

اختيارٌ مِن مُتعَدِّدٍ: أيُّ تَرْتيبٍ مِمّا يأتي يُعَبِّرُ عَنْ مَواقِعِ النِّقاطِ الظّاهِرَةِ في الشَّكْلِ؟

أ) ٢,١ ، ٢,٢ ، $٢\frac{١}{٤}$ ‏ ‏ ‏ جـ) ٢,٠١ ، ٢,٠٤ ، $\frac{٧}{١٠٠}$

ب) ٢,١ ، $٢\frac{٤}{١٠}$ ، ٢,٧ ‏ ‏ ‏ د) $٢\frac{١}{١٠}$ ، ٢,١ ، $٢\frac{٤}{١٠}$

قارِنْ بَيْنَ كُلِّ عَدَدَيْنِ مِمّا يَأتي. اسْتَعْمِلِ الإشاراتِ < ، > ، =:

$\frac{٤}{١٠}$ ⬤ $\frac{١}{٢}$ ‏ ‏ ‏ $\frac{٢}{٤}$ ⬤ $\frac{٣}{٤}$

اكْتُبْ كُلاً مِنَ العَدَدَيْنِ الكَسْرِيَّيْنِ الآتِيَيْنِ عَلى صورَةِ كَسْرٍ غَيْرِ فعلِيٍّ.

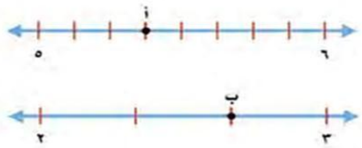
$٢\frac{٣}{٤}$

اختيارٌ مِن مُتعَدِّدٍ: ما ناتِجُ تَقْريبِ الْعَدَدِ ٦٧,٣٤ إلى أَقْرَبِ عُشْرٍ؟

أ) ٦٧ ‏ ‏ ‏ جـ) ٦٧,٣٤

ب) ٦٧,٣ ‏ ‏ ‏ د) ٦٨

اكْتُبِ العَدَدَ الكَسْرِيَّ، وَالكَسْرَ غَيْرَ الفعلِيِّ الَّذي تُمَثِّلُهُ كُلٌّ مِنَ النُّقْطَتَيْنِ أ وَ ب :



حَوِّلْ إلى كُسورٍ عَشْرِيَّةٍ:

$٤\frac{٧}{١٠}$ ‏ ‏ ‏ $١٨\frac{٦٥}{١٠٠}$

Appendix 2

The Arabic version of the Attitude Towards Mathematics questionnaire

<u>اتجاهاتي نحو تعلم الرياضيات</u>

(البعدي)

عزيزي الطالب:

تهدف هذه الإستبانة للتعرف على رأيك و شعورك نحو تعلم الرياضيات.

لكل شخص طريقته الفريدة في التفكير لذا من المهم لدينا معرفة آراءك.

ستجد مجموعة من العبارات ، الرجاء منك التفكير بها. كما أود تذكيرك أنه ليس هناك إجابة خاطئة أو صحيحة و لكن المهم أن تضع ما يعبر عن رأيك. الرجاء عدم التحدث عن إجابتك مع الأشخاص الآخرين.

<u>الرجاء القيام بالتالي:</u>

1- اقرأ كل عبارة بتأني و أجب عن كل سؤال.

2- لكل عبارة ضع علامة (✓) في الصندوق الذي الذي يمثل رأيك أو شعورك حيال السؤال.

قبل البداية الرجاء تعبئة الخانات التالية:

الاسم	
تاريخ الميلاد	
اسم المدرسة	
الصف و الفصل	
اسم شريكك في تعلم الرياضيات	

م	العبارة	موافق				غير موافق
		5	4	3	2	1
1	أحب أن أحل مسائل الرياضيات					
2	أحب أن أتخصص في الرياضيات مستقبلاً					
3	الرياضيات مهمة لكل الناس					
4	أحب أن أقضي وقت أكبر في تعلم الرياضيات					
5	على الطالب أن يكون ذكي ليحل مسائل الرياضيات					
6	أحب أن أحل مسائل الرياضيات في المنزل					
7	مسائل الرياضيات صعبة جداً					
8	من السهل حل مسائل الرياضيات					
9	تعلم مادة الرياضيات يساعدني في حياتي					
10	أحتاج الرياضيات أثناء التسوق					
11	مادة الرياضيات جعلت حياتي أسهل					
12	علي أن أعمل الكثير لكي أحل مسائل الرياضيات					
13	أحب أن أشاهد البرامج التي تتعلق بالرياضيات في التلفاز					
14	أحب أن ألعب البرامج التي تتعلق بالرياضيات في الكمبيوتر					
15	نادي تعلم الرياضيات في المدرسة فكرة متميزة					
16	مادة الرياضيات تجعلني أفكر					
17	أنا جيد في مادة الرياضيات					
18	يسعدني أن أستلم لعبة كمبيوتر تحوي ألعاب تتعلق بالرياضيات					
19	أقوم بحل الكثير من مسائل الرياضيات في المدرسة					
20	بإمكان الرياضيات أن تجعل العالم أفضل					

Appendix 3

The English version of the Attitude Towards Mathematics questionnaire.

Attitude Towards Mathematics questionnaire

We're currently working on planning group work activities in the mathematics for you to do this year. To get the activities right it would help to know what you feel about your work and learning mathematics.

Not everyone thinks the same, so it is important that we know what you think.

We have written some statements for you to think about. There are no right or wrong answers, but it is important that you put down what you think, and don't talk about your answers with other people.

This is what you have to do:

Read each statement and answer each question

For each, put a tick in the box that is closest to what you think or feel

Before you start, write your name and the other information needed in the boxes below.

First name	surname	Date of birth

Name of School	Class	Date

The name of my maths partner is	

Attitude Towards Mathematics questionnaire

For each statement about mathematics, put a tick in one of the boxes on the 5 points scale to show how much you agree or disagree	Agree				Disagree
	5	4	3	2	1
I like to do maths					
I would like to be mathematician					
Maths is good for everybody					
I like to spend more time learning maths					
You have to be clever to do maths					
I often do maths at home					
Maths is just too difficult					
It is easy to solve number problem in maths					
Doing maths help us in life					
Shopping need maths					
Our life is easier thanks to maths					
We have to do too much work in maths					
I like to watch maths programmes on TV					
I like playing maths game on computer					
School maths club are good idea					
Maths makes me think					
I am good at maths					
I would like to be given a maths computer game as a present					
We do too much maths at school					
Maths can make the world better					

Appendix 4

The Arabic version of the Attitude Towards Mathematics Learning Partner questionnaire

<u>اتجاهاتي نحو شريكي في تعلم الرياضيات</u>

(البعدي)

عزيزي الطالب:

نخطط في الوقت الحالي لتكوين مجموعات عمل من أجلك في مادة الرياضيات خلال الفصل الدراسي الثاني من هذا العام الدراسي و لأجل ذلك سيساعدنا كثيراً معرفة شعورك حيال شريكك في تعلم الرياضيات.

لكل شخص طريقته الفريدة في التفكير لذا من المهم لدينا معرفة آراءك.

ستجد مجموعة من العبارات ، الرجاء منك التفكير بها. كما أود تذكيرك أنه ليس هناك إجابة خاطئة أو صحيحة و لكن المهم أن تضع ما يعبر عن رأيك. الرجاء عددم التحدث عن إجابتك مع الأشخاص الآخرين.

<u>الرجاء القيام بالتالي:</u>

1- اقرأ كل عبارة بتأني و أجب عن كل سؤال.
2- لكل عبارة ضع علامة (✓) في الصندوق الذي يمثل رأيك أو شعورك حيال السؤال.

قبل البداية الرجاء تعبئة الخانات التالية:

الاسم	
تاريخ الميلاد	
اسم المدرسة	
الصف و الفصل	
اسم شريكك في تعلم الرياضيات	

م	العبارة	أوافق				لا أوافق
		5	4	3	2	1
1	شريكي في تعلم الرياضيات رياضي متميز					
2	شريكي في تعلم الرياضيات متميز في الرياضيات					
3	شريكي في تعلم الرياضيات ذكي					
4	شريكي في تعلم الرياضيات يفضل اللعب لوحده في الساحات					
5	شريكي في تعلم الرياضيات يستطيع الجري بسرعة					
6	الجميع يحب شريكي في تعلم الرياضيات					
7	الرياضيات صعبة بالنسبة لشريكي في تعلم الرياضيات					
8	شريكي في تعلم الرياضيات يمتلك عضلات قوية					
9	لا أعتقد أن شريكي في تعلم الرياضيات ذو سلوك مؤدب					
10	سأحب العمل مع شريكي في تعلم الرياضيات					
11	شريكي في تعلم الرياضيات ليس لديه أصدقاء كثر					
12	أتطلع للعمل مع شريكي في تعلم الرياضيات					
13	شريكي في تعلم الرياضيات مشهور					
14	بقية الطلاب في الصف أصدقاء لشريكي في تعلم الرياضيات					
15	شريكي في تعلم الرياضيات ذكي					
16	لا أعتقد أن شريكي في تعلم الرياضيات يمتلك جسماً صحياً					
17	أنا و شريكي في تعلم الرياضيات سنعمل بشكل جيد معاً					
18	شريكي في تعلم الرياضيات ليس متميزاً في التربية البدنية					
19	يعتقد معلم الرياضيات أن شريكي في تعلم الرياضيات طالب مؤدب					
20	شريكي في تعلم الرياضيات ليس جيداً في الأعمال الدراسية					

Appendix 5

The Arabic version of the Attitude Towards Mathematics Learning Partner questionnaire

Attitude Towards Learning Partner questionnaire

We're currently working on planning group work activities in the mathematics for you to do this year. To get the activities right it would help to know what you feel about your work and your maths partner.

Not everyone thinks the same, so it is important that we know what you think.

We have written some statements for you to think about. There are no right or wrong answers, but it is important that you put down what you think, and don't talk about your answers with other people.

This is what you have to do:

Read each statement and answer each question

For each, put a tick in the box that is closest to what you think or feel

Before you start, write your name and the other information needed in the boxes below.

First name	surname	Date of birth

Name of School	Class	Date

The name of my maths partner is	

Attitude Towards Learning Partner Questionnaire

For each statement about your maths partner, put a tick in one of the boxes on the 5 points scale to show how much you agree or disagree	Agree				Disagree
	5	4	3	2	1
I like my maths partner					
My maths partner is good at sports					
My maths partner is good at maths					
My maths partner is brainy					
My maths partner tend to play by themselves in the playground					
My maths partner can run fast					
People like my maths partner					
Mathematics is difficult for my maths partner					
My maths partner has strong muscles					
I do not think my maths partner behaves very well					
I will like working with my maths partner					
My maths partner does not have many friends					
I look forward to working with my maths partner					
My maths partner is popular					
People in my class are friends with my maths partner					
My maths partner is clever					
I don't think my maths partner is very fit					
My maths partner and I will work well together					
My maths partner is not good at PE					
My teacher thinks my maths partner is well behaved					
My maths partner isn't good at school work					

Appendix 6

The Arabic version of the People in Your Class questionnaire

<u>زملاءك في الفصل</u>

عزيزي الطالب:

الرجاء استخدام الدقائق التالية للتفكير حول علاقتك بالطلاب الآخرين في فصلك و الموجودون في القائمة خلف هذه الورقة.

ستجد بجوار كل اسم عدد من المربعات ، كل مربع يحوي سؤالاً في أعلى القائمة. هذه الأسئلة تسألك حول الطريقة التي تعرف بها زميلك في الفصل.

الرجاء ضع علامة (✓) في الصناديق التي تمثل علاقتك بكل شخص في القائمة.

سيقوم المعلم في الفصل بشرح الكيفية بتفصيل أكثر ، و في حال وجود أي سؤال الرجاء سؤال معلمك.

الاسم	
تاريخ الميلاد	
اسم المدرسة	
الصف و الفصل	
اسم شريكك في تعلم الرياضيات	

م	اسم الطالب	أعمل معه خلال تعلم الأقران	أحب العمل معه خلال حصة الرياضيات	أحب العمل معه خلال الحصص الأخرى	أحب مشاركته وقت الفسحة	أحب مشاركته الوقت خارج المدرسة	أحب أن أذهب معه إلى المسجد
1							
2							
3							
4							
5							
6							
7							
8							
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30							

Appendix 7

The English version of the People in Your Class questionnaire

People in Your Class questionnaire

Notes for person administering questionnaire

This questionnaire is intended to find out something about how well pupils who are participating in the project get on with others in their class, both in and out of school- especially those who they have collaborated with in peer learning activities as part of their lessons. Because it is important to get some idea about each pupil's degree of liking for all the others in their class, we need to have them work through the entire class list – otherwise they might well forget about somebody. In addition, we also need to know who each individual has actually engaged in peer learning with. This means that the questionnaire is more complicated to fill in than anything pupils might have come across previously.

For this reason, it is important to introduce the questionnaire before asking them to fill it in, and make sure that they understand what to do. For the sake of clarity, each question they need to think about is listed separately, but they will probably find it easiest simply to work down the class list, ticking the boxes for each heading that applies to a given person. It will therefore be best if you steer them towards doing this. For the first few people on the list, they may need to keep referring back to the questions, but after a while they should find it straightforward to remember what each column refers to.

It will be useful to clarify the following points about the questions with them before they start:

1) Explain what is meant by working with someone as part of a paired maths – this is not just sitting together, but the actual person that they are carrying out joint activities with during the paired mathematics
2) Make sure they understand that for question 2 they can tick all pupils they work with both during paired maths and during other maths
3) Make sure that they understand that for question 3 they can tick whom they like to work with in ANY other lessons

People in Your Class questionnaire

Before you start, write your name and the other information needed in the boxes below:

First name	surname	Date of birth

Name of School	Class	Date

Pease take a few minutes to think about how well you get on with the different people in your class, who are all listed on the next page.

You'll notice that alongside each name on the list are number of boxes, one for each of the questions at the top of the page. These questions ask you about different ways in which you know each person.

What we'd like you to do is put your name at the top of the page in the space provided, and then work down the list, putting ticks in all the boxes that apply to each person. For example, if the first person is someone you like working with in maths, spending time with at school bereaktime, and spending time with out of school, then you would tick boxes 2, 4 and 5.

You don't need to tick the boxes against your own name! So for instance you would fill it in like this, putting a tick next to the names of classmates that you like working or playing with like this:

Name	Play with at break	Work with in class	Play with out of school	See at local clubs	Know family of	See at local events
Peter X	✓	✓	✓	✓	✓	✓
Jane Y	✓	✓				
Joe B	✓		✓	✓	✓	
Kathryn A		✓				
Mhairi T	✓	✓	✓	✓	✓	✓

For each person in the box, tick the box under the statement if it is true for you:

Name	Work with during paired maths	Like working with in maths	Like working with in other lessons	Like being with at school break	Like being with out of school

Appendix 8

A copy of the students' parents agreement for their children to participate in the study

المكرم ولي أمر الطالب / وفقه الله

السلام عليكم و رحمة الله و بركاته ..... و بعد :

فأنا الباحث / محمد بن عبدالعزيز العيد ، المحاضر في كلية التربية – جامعة الملك فيصل بالأحساء ، و المبتعث لدراسة الدكتوراه في جامعة يورك – المملكة المتحدة.

و حيث أني بصدد القيام ببحث يتعلق بمعرفة أثر استخدام استراتيجية تعلم الأقران مع أو بدون اليدويات على تعلم الرياضيات لطلاب المرحلة الإبتدائية في محافظة الأحساء.

و قد تم التنسيق مع إدارة التربية و التعليم بمحافظة الأحساء لاختيار مجموعة من الفصول لتطبيق تجربة تدريسية. و قد تم اختيار الفصل الذي يدرس فيه ابنكم كأحد هذه الفصول.

و حيث أن موافقتكم على مشاركة ابنكم في هذه الدراسة تهمني شخصياً و تهم كلاً من إدارة جامعة يورك و جامعة الملك فيصل ، لذا تم إرسال هذه الرسالة للتأكد من موافقتكم على اشتراك ابنكم في هذه الدراسة.

عزيزي ولي الأمر:

أحب أن أؤكد لكم أن التجربة لن تؤثر سلباً على مستوى ابنكم الدراسي ، حيث أن الدراسات التربوية على مستوى العالم تؤكد أن الاستراتيجية التي سيتم تطبيقها من خلال التجربة تركت أثراً إيجابياً على تعلم الرياضيات.

كما أؤكد أنه سيتم التعامل مع جميع المعلومات الشخصية و البيانات المتعلقة بكم و بإبنكم وفق أعلى شروط الخصوصية و السرية المعمول بها في جامعة يورك.

سيتم اشراك ابنكم في اختبارين تحصيليين : أحدهما قبل التجربة ، و الآخر بعدها ، و لن تؤثر نتيجة الإختبار على تقييم إبنكم الدراسي. كما سيتم تطبيق استبانة لمعرفة اتجاهات ابنكم نحو تعلم مادة الرياضيات قبل التجربة و بعدها. كما أنه قد يتم اختيار ابنكم من ضمن عينة لعمل مقابلات شخصية لمعرفة آراء الطلبة نحو الاستراتيجية المستخدمة.

يسرني و يسعدي استقبال أي استفسار لمزيد من الإيضاح على البريد الإلكتروني (maa522@york.ac.uk) أو على رقم الجوال (0503903581).

أنا ولي أمر الطالب /

◯ أوافق ◯ لا أوافق على اشتراك ابني في التجربة التدريسية.

الاسم/ التوقيع/

وفي الختام أشكر لكم تعاونكم لإنجاح هذه الدراسة على أمل أن تساعد هذه الدراسة على الرقي بمستوى ابنكم في مادة الرياضيات.

و الله الموفق

الباحث/ محمد بن عبدالعزيز العيد

المحاضر في كلية التربية – جامعة الملك فيصل

الباحث التربوي في جامعة يورك الممكلة المتحدة

Appendix 9

The Ministry of Education approval to carry out the research study in AlAhsa schools

المملكة العربية السعودية
وزارة التربية والتعليم
(٢٨٠)
إدارة التربية والتعليم بمحافظة الأحساء (بنين)
وحدة التخطيط والتطوير التربوي
البحوث التربوية

وزارة التربية والتعليم
Ministry of Education

الرقم : ٣٢٦٨٠٢١٧ / ٩
التاريخ : ١٨/٤/١٤٣٢هـ
المرفقات : بدون

تعميم لجميع المدارس الابتدائية

إلى : المكرم مدير/ مدرسة وفقه الله

من : المدير العام

بشأن : تسهيل مهمة الباحث /محمد بن عبدالعزيز العيد

السلام عليكم ورحمة الله وبركاته . . . وبعد

إشارة إلى خطاب عميد كلية التربية بجامعه الملك فيصل رقم ٧٥١/٢/١/٩ وتاريخ ١٤٣٢/٤/١٥هـ ،المتضمن أن المحاضر/ محمد بن عبدالعزيز العيد ، يقوم بإجراء بحث بعنوان:(أثر استخدام استراتيجية تعلم الأقران مع أوبدون اليدويات على تعلم الرياضيات في مدارس محافظة الاحساء) .

عليه نأمل التكرم بتسهيل مهمته في تطبيق ادوات البحث وإجراء الدراسه التجريبية وذلك وفق التعليمات . للاستفسار: يمكنكم التواصل مع الاستاذ / محمد بن عبدالعزيز العيد على الجوال/٠٥٠٣٩٠٣٥٨١ او على البريد الالكتروني : aleid555@hotmail.com

ولكم خالص تحياتي ،،،

أحمد بن محمد بالغنيم

ص / لعميد كلية التربية بجامعه الملك فيصل بالاحساء للاحاطه
ص / للمساعد للشؤون التعليمية مع التحية
ص / للمساعد للشؤون المدرسية مع التحية
ص / وحدة التخطيط والتطوير التربوي (البحوث التربوية)
ص / للباحث: محمد بن عبدالعزيز العيد للاحاطه

Appendix 10

A copy of the teachers' agreement to participate in the study

الأخ الأستاذ / وفقه الله

السلام عليكم و رحمة الله و بركاته ..... و بعد :

فأنا الباحث / محمد بن عبدالعزيز العيد ، المحاضر في كلية التربية – جامعة الملك فيصل بالأحساء ، و المبتعث لدراسة الدكتوراه في جامعة يورك – المملكة المتحدة.

و حيث أني بصدد القيام ببحث يتعلق بمعرفة أثر استخدام استراتيجية تعلم الأقران مع أو بدون اليدويات على تعلم الرياضيات لطلاب المرحلة الإبتدائية في محافظة الأحساء.

و قد تم التنسيق مع إدارة التربية و التعليم بمحافظة الأحساء لاختيار مجموعة من الفصول لتطبيق تجربة تدريسية. و قد أسعدني اختيار الفصول التي تدرسها للمشاركة في هذه التجربة.

و حيث أن موافقتكم على مشاركتكم في هذه الدراسة تهمني شخصياً و تهم كلاً من إدارة جامعة يورك و جامعة الملك فيصل ، لذا تم إعداد هذا الخطاب للتأكد من موافقتكم على اشتراك فصولكم في هذه التجربة.

أؤكد أخي المعلم أنه سيتم التعامل مع جميع المعلومات الشخصية و البيانات المتعلقة بك و بطلاب الفصول التي تدرسها وفق أعلى شروط الخصوصية و السرية المعمول بها في جامعة يورك.

التجربة تقتضي عمل التالي:

- استبانة لقياس اتجاهات معلمي الرياضيات نحو تدريس مقرر الرياضيات ، ينفذ قبلياً و بعدياً.
- مقابلات شخصية مع معلمي مادة الرياضيات و الطلاب.
- اختبار تحصيلي ينفذ قبلياً و بعدياً على الطلاب.
- استبانة لقياس اتجاهات الطلاب نحو تعلم الرياضيات تنفذ قبلياً و بعدياً
- كما سيتخلل التجربة زيارات ميدانية للمعلمين لمشاهدة الأداء و جمع الملاحظات.

ستجد تفاصيل أكثر تتعلق بالتجربة التي سيتم إشراككم بها كما يسرني و يسعدي استقبال أي استفسار لمزيد من الإيضاح على البريد الإلكتروني (maa522@york.ac.uk) أو على رقم الجوال (0503903581).

أنا المعلم / في مدرسة /

○ أوافق ○ لا أوافق على اشتراك الفصول التي أدرسها في التجربة و التعاون مع الباحث.

الاسم/ التوقيع/

وفي الختام أشكر لكم تعاونكم لإنجاح هذه الدراسة على أمل أن تساعد هذه الدراسة على الرقي بمستوى ابنكم في مادة الرياضيات.

و الله الموفق

الباحث/ محمد بن عبدالعزيز العيد

المحاضر في كلية التربية – جامعة الملك فيصل، الباحث التربوي في جامعة يورك المملكة المتحدة

Appendix 11

A copy of the letter from my supervisor to the Saudi Culture Bureau

UNIVERSITY OF
STIRLING

The Stirling Institute of Education,
University of Stirling,
Stirling,
FK9 4LA
28th February 2010

Dear Sir,

RE: Mohammed Aleid, PhD student, University of Stirling

I write in unreserved support of Mohammed's application for funding to return to Saudi Arabia in order to undertake data collection as an essential part of his study for PhD. Mohammed has proven to be a dedicated student. His work has progressed well. He is diligent and is producing work of a high standard. Mohammed has now completed a substantial part of his literature review. The next stage of his work will involve the planning and implementation of an experimental study in Saudi classrooms. This data collection will form an essential aspect of his study. It will allow him to assess the effect of variables on numeracy attainment in authentic Saudi school contexts. Mohammed is now ready to undertake this next phase of his study. The investment you will make in Mohammed will be money well spent. I am confident that he will use the time productively. If you require further information then please do not hesitate to get in touch.

Yours faithfully,

Dr , Allen

Senior Lecturer,
The Stirling Institute of Education,
University of Stirling,
Stirling, FK9 4LA

Appendix 12

The English translation of the teachers' interview schedule

What do you think of using peer tutoring, manipulatives, or both of them combined?

What are the advantages and disadvantages of using peer tutoring, manipulatives, or both of them combined?

How can teachers gain these advantages?

What can prevent teachers from gaining these advantages?

If there are any disadvantages, what are these and how can teachers avoid them?

What is your experience of using peer tutoring, manipulatives, or both of them combined?

How and why can they affect your teaching performance?

How and why can they affect your students' learning?

Do you suggest the use of peer tutoring, manipulatives, or both of them combined to other teachers? Please give a reason for your answer.

What are the barriers you face when you apply peer tutoring, manipulatives, or both of them combined.

How has the education policy in Saudi affected your use of peer tutoring, manipulative, or both of them combined?

Has the curriculum design affected your use of peer tutoring, manipulatives, or both of them combined.

Appendix 13

The English translation of the students' interview schedule

What do you think of mathematics? Please give a reason for your answer.

What do you think of peer tutoring, manipulatives, or both of them combined?

How have they affected your learning of mathematics?

Have your relationships with other students become better or worse? Please give a reason for your answer?

Has your relationships with your teachers become better or worse? Please give a reason for your answer?

What is your experience of using peer tutoring, manipulatives, or both of them combined?

What is your opinion of the performance of your teacher after the use of peer tutoring, manipulatives, or a combination of the two?