The University of Huddersfield

School of Education and Professional Development

An Assessment of the Effectiveness of Cooperative Learning Strategies in Promoting Problem-Solving Skills and Achievement in Mathematics

A thesis submitted to the University of Huddersfield in partial fulfilment of the requirements for the degree of Doctor of Philosophy

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December 2002

Abstract

The study investigates the rationale and value of using cooperative learning strategies in the mathematics classroom with special reference to its effectiveness in promoting problem solving skills and levels of achievement in mathematics. In this it is compared with traditional teaching methods. The study sample was composed of 348 eighth grade students in eight classes from two separate female and male schools and included female and male teachers. Two female and two male teachers were trained in the use of cooperative learning strategies in their classes during the implementation of the experiment, while the other four teachers had been asked to keep using their usual traditional teaching methods. The experiment took place within two scholastic semesters and the same mathematical content was covered by the two groups within the experiment. Pre- and post-mathematical achievement tests were employed to assess students' progress in achievement and problem solving skills. Also, a programme evaluation questionnaire was applied at the end of the experiment for all students involved. In addition to the quantitative methodology, the study also addressed qualitative issues. All the teachers involved in the experiment, and a sample of students, were interviewed. Lesson observations were conducted within the research programme to evaluate the implementation of the cooperative learning strategies and teachers' and students' responses towards it. In addition, teachers were asked to record weekly diaries to assess their judgement on student progress within the experiment.

The researcher recognises that teachers and students who apply cooperative learning strategies might be strongly motivated and be more enthusiastic by the very fact of trying a new strategy. Consideration was, therefore, given to this point at all stages. The study tries to determine if such strategies are really valuable in the mathematics classroom, allowing for all the variables, and have measurable effects in promoting problem solving skills and achievement in mathematics.

The study demonstrates that cooperative learning strategies enhance the teaching and learning process by transferring focus from a teacher-centred situation into a student- centred learning context. This enriches the cognitive, competitive and social interaction and, hence, develops outcomes in the cognitive, affective, motivational and social domains. The study proved the positive impact of applying such strategies in enhancing mathematical achievement and promoting problem solving skills compared with the impact made by traditional teaching strategies. Cooperative learning strategies could offer all students with different abilities the opportunities to cooperate, interact and participate in the mathematics lesson. This gave them a chance to do mathematics by themselves, speak their thoughts, offer and receive explanations, introduce several procedures for solving problems and, hence, profit from the mathematical knowledge available in the group as a whole. The new learning approach encouraged students to challenge problems and provided them with the opportunities to speak mathematically, to understand the mathematical concepts and rules and to use them. Results from the study also demonstrated that cooperative learning developed other skills. It improved student interaction, communication and social skills and built more positive attitudes towards learning compared with the traditional methods. Developing student behaviour and personality was, therefore, an important additional feature.

The study illustrated that cooperative learning strategies help to solve problems faced by teachers in classroom management.

As expected, the research showed that outcomes differed from case to case and from one situation to another. The academic ability of students and the quality of mathematical material played an obvious role emphasising positive or negative affects. On the other hand, gender differences examined in the study showed that, despite female students achieving better results, male students actually displayed more positive attitudes toward mathematics. But again, female students were more enthusiastic in applying cooperative learning.

The study is the first of this nature to be applied in Jordan and has several implications for theory and practice. No teaching method is the best, but it is recommended to provide teachers with professional training programmes to apply more developmental teaching methods effectively and to modify mathematical textbooks and teachers' guides for the use of different teaching methods. It is recommended that more research be carried out in different fields of study to concentrate on improving the quality of learning and enhancing problem solving skills.

Acknowledgement

First of all, I would like to thank 'Allah' for enabling me to finish my research.

I owe a gratitude to Director of Studies Dr. Mike Breckin for his continuous help, inspiring guidance, stimulating suggestions, fruitful discussion and unfailing encouragement at all stages of the research.

I would like to acknowledge my thanks to Head of Research, Professor Cedric Cullingford for his support, advice and help. My thanks are also extended to Dr. David Lord and Mr. Ron Thompson for their suggestions and advice. Also special thanks to Mrs Rosalind Watt for her help and advice.

My thanks to the staff of the School of Education and Professional Development at the University of Huddersfield for their cooperation and assistance.

I wish to thank the Hashemite University for sponsoring me and providing me with the opportunity to continue my study.

Deep appreciation to all the participators at the Jordanian schools involved in the experiment. My thanks to the head-teachers, teachers and students for their assistance, efforts, cooperation and participation.

Dedication

To my Husband, my Lover 'Dr. Nedal' who supports me with all of love, kind, help, patient and encouragement for successful completion of my research.

To my lovely sons, who are always the light which light up my life for best. My kids Omar, Aws and Qussai.

To my faithful and great parents, my sister, and my brothers who always have given me their ongoing love, encouragement and prayers.

I hope all of them will accept it with love

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Definition of Terms

Within the content of this present study, the following terms will be used as they are defined below.

Cooperative learning: an instructional approach in which students who are assigned to their heterogeneous groups work together within their teams to solve a problem, complete a task or achieve a common goal.

Traditional teaching method: the usual teaching methods that teachers use to apply in their mathematics classes where information is presented didactically by teachers. It was found that the usual strategies focus on lecturing and expository techniques in introducing the lesson and using the discussion techniques by asking questions during the exploration stage.

Teaching strategies: all teacher's objectives, moves, procedures and tools used from starting the lesson until finishing it, to achieve the goals including the class organisation and management, the learning atmosphere and the students' response.

Cooperative learning strategies: the model of implementation that teachers were trained to use within the experiment. It was a mix of several cooperative strategies generated from different cooperative learning methods to achieve most of the basic components for an effective group work.

Primary stage: the compulsory primary stage in schooling in Jordan extends for ten years. Students' ages are approximately 6- 16 years old.

Upper primary stage: primary stage extends for the last four primary years. Students' ages are approximately 12- 16 years old.

Grade eight: the eighth year of the primary stage referred to as class eight. Students' age is approximately 14 years old.

Cooperative group: teachers or students involved in the experiment that applied the cooperative learning strategies.

Traditional group: teachers or students involved in the experiment which applied the traditional teaching methods.

Chapter One

Introduction

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Introduction

1. Introduction

Improving the teaching and learning process is one of the most basic aims of mathematical educational research. Such research has always had its roots in the mathematics classroom (Nickson, 2000). The conflict between researchers all over the world is still searching for the effect of different factors that influence the teaching and learning process, such as: students' ability, social class, gender, cultural resources, motivation, teachers' characteristics and teaching skills, the effects of the curriculum, the effects of the learning style and different teaching approaches which influence the nature of knowledge that students develop and the ways that students approach new situations. Instructional approaches and strategies involved in the mathematical classroom are one of the most important factors that might influence the learning process and affect students' outcomes. However, these strategies must always be directed to improve the quality of students' learning and promote a high-level of thinking process. Although several research studies all over the world had suggested the cooperative learning as a successful classroom instructional strategy on students' general achievement, there was a lack of empirical studies in such research in Jordanian mathematics classrooms, especially to search for its effectiveness in promoting problem solving skills in mathematics, that reflect to what extend the quality of learning has been improved. Moreover, the lack of applying cooperative learning strategies in Jordanian mathematics classrooms was an impetus to search for the rationality to use such strategies in mathematics.

The contents of this chapter include several sections that provide the reader with a background to answer the following questions: Why is the study necessary and how has it come about? What are the aims of the study? What are the research questions? What are the researcher's assumptions? What are the limitations of the study? Moreover, what is the context of the study?

1.1 Importance and Need of the Study

According to the review of the literature in mathematics education in general, and regarding the researcher's observation based on her own experience about mathematics education in Jordan in particular, the following problems and issues emerged which give rise to the importance and need of the study.

- **General Weakness in Mathematics**

Although "mathematical education has become an established subject" from the view point of both mathematics as a subject and education as a subject, there is still a need for specialised study in its own right (Orton, 1992). Moreover, within mathematics education there is a great belief that many students cannot use the mathematics they learn at school in situations outside the classroom (Boaler, 1997). Students cannot easily make the link between theory and practice. Students cannot understand well the concepts, symbols, laws, procedures and algorithms to use them in solving problems (Tall and Razali, 1993). The analysis of the problems of language in teaching mathematics is also considered an important activity for students (Wain and Woodrow, 1980), where the language of mathematics is a specific language which is not easy to be understood and dealt with correctly. Actually, students in Jordan are like any other students who have difficulties in learning mathematics. Most teachers and parents complain of the weakness of students in mathematics, especially to use mathematics in the high-level thinking process. In addition, no one can ignore the fact that a high percentage of students who get failures in the General Secondary Certificate in Jordan mostly fail in the mathematics examination.

- **Failing in Applying Realistic Mathematics**

Mathematics is a realistic and virtual subject that is used in our daily life situations. We use mathematics every where and all the time. There is a need to use mathematics to make calculations, to deal with time, to apply to other subjects, to use it in marketing, to serve jobs like engineering, business, industry, medicine, education, economics, trading, nitration, physical sciences, law enforcement, and so on. Therefore, it is very important for humans to use mathematics effectively in every day knowledge of the world outside of the classroom. Charles and Lester (1984) pointed out that the basic goal of mathematics education is to provide students with an appropriate mathematics background to allow them to continue their careers in different areas. Cooper and Dune (2000) found that several research studies show that students usually fail to apply realistic mathematics and maybe fail to demonstrate that they know and understand the mathematics they gained from perspectives in the classroom. Mathematical education as a form of knowledge can cover any application of mathematics in real situations. In recent years, the change in mathematical educational aims to shift from learning particular problems towards enhancing the ability to understand and make a link between the learning models themselves and then using them in solving different forms of problem under consideration. Mathematics education is generated from everyday situations and deals with different forms of day-to-day life situations. Students need to realise that mathematics can be related to other aspects of the world, to other disciplines and techniques (Wain, 1978). Unfortunately, most students in Jordan are not challenged to apply mathematics learning to real life problems and applications.

- **Weakness and Difficulties in Mathematical Problem Solving**

The basic aim in teaching mathematics is to help students to learn how to describe, tackle and, ultimately, solve problems which require the use of mathematical knowledge and techniques. Many researchers try to investigate why students find problem solving so difficult and why it is a hard subject to be learned. They try to develop and devise a workable and effective way to teach problem solving. Also, they try to promote problem solving skills for the students to make them better problem solvers and to increase teachers' appreciation of the importance of problem solving and their ability to teach it in a correct way (Charles and Laster, 1984).

Lester, Jr. (1980) pointed out that, despite students' basic computation skills being sometimes good, their performance in problem solving and their application of computational skills is very low. To give a reason to that, he likened the situation to a baseball player who cannot become a good player if he has never played baseball. So, students cannot expect to learn how to use attained skills if they never have a chance to use them.

Mathematics is one of the most important subjects in our schools. In Jordan, it is considered a basic subject which is taught at all stages. Most students have many difficulties in understanding mathematics and they have limited ability in problem solving skills. From previous experience and observations, the author has noted that many students have difficulties in solving non-routine problems and in exploring open-ended situations for conjectures and testing them with data. Moreover, mathematics is considered by teachers and learners as one of the most difficult subjects in school. Teaching and learning processes in Jordan still need more effort to improve the quality of learning where most students are very weak in solving mathematical problems.

- **Possibility of Enhancing Mathematical Problem Solving Skills through Cooperative Learning**

Many researchers all over the world have drawn attention to the advantages which cooperative learning strategies can have over the traditional and individualised forms of support that have been provided for students who encounter difficulties in the mathematics classroom. Traditional teaching emphasises practice in manipulating expressions and algorithms as a fundamental base to solving problems. It ignores the fact that knowledge often arises from engaging with problems. Instead of skills in computation preceding word problems, experience with problems can help to promote computational ability and skills (Runesson, 1997). In other words, current strategies for teaching mathematics might be reversed. Johnson and Johnson (1990) pointed out that talking through mathematical problems with classmates helps students to understand how to solve problems correctly. Explaining reasoning strategies and analysing problems to classmates often results in discovering learning, using strategies in higher level thinking and engaging in meta-cognitive thought. Furthermore, such discussion requires students to use the language of mathematics and demonstrate their mathematical reasoning to others. In these circumstances, students are expected to develop their mathematical problem solving skills through cooperative work.

In the 1980s and early 1990s there was a demand for changing the mathematics curriculum all over the world. There had been a shift away from looking at mathematics as a subject that consists of concepts and mathematical competencies equal to computational skills, to speaking about "mathematical power ". This term denotes the individual's ability to solve non-routine problems by using different mathematical methods, to explore, to communicate and to reason logically (Runesson, 1997). Terwel (1990), when he described the main features of mathematics curriculum for 12 – 16 years olds, found that cooperative learning was an important aspect of the curriculum.

- **The Need to Improve the Quality of the Teaching and Learning Process in Jordanian Mathematics Classrooms**

Although there are several teaching methods, little variety exists in the methods of teaching used in Jordan. Teachers usually use traditional teaching methods in mathematics and concentrate on lectures. In addition, there is an educational political desire to use a student-centred approach, where teaching in Jordan still uses the teacher-centred approach.

Teachers often spend most of the time in the lesson lecturing, giving examples and talking about problems without giving the students enough time to do mathematics by themselves. In recent years, the Ministry of Education in Jordan realised the need to reach a student-centred situation and encouraged such learning by paying attention to using new teaching methods that help students to discover, work, use logical and critical thinking, analyse, take decisions, explain, measure and classify by themselves, applying such activities in order to maximise their learning outputs and to improve their learning skills. These outputs are based on the academic achievement field. On the other hand, using new teaching methods may play a major role in some progressing of the students' social and personal behaviour. In addition, they may give the student a chance to gain academic and non-academic achievements. These aims were the starting point for the Jordanian Educational Developmental Plan (1989-1998) that was a comprehensive plan in its scopes and its programmes. The aims are to promote the standard of general educational outputs, including achievement and performance and working together with the scientific and technological development to interact with the international cultural development. On the other hand, the programmes of this plan aim to qualify teachers to higher degrees and training them in how to use the new curricula, use different teaching approaches and methods and, moreover, to benefit from the advantages of the studies' outcomes and from the scientific and educational research (Ministry of Education - Jordan, 1988). Actually, the most important aims of the Educational Developmental Plan are to improve the quality of the teaching and learning process as a developmental in-service training programme, on the one hand, and as a development plan for the quality of students' learning, on the other.

- **Failure in Applying Cooperative Learning Strategies in Mathematics and the Requirement for In-Service Training**

Using cooperative learning in the mathematics classroom is one of the teaching approaches that the Ministry of Education in Jordan tries to apply, but, unfortunately, there are no special training courses for the teachers about the cooperative learning approach which include many of its components and its basic elements in how to use it correctly in the classroom. Moreover, most teachers have little information about it and they believe that it is just a way to collect the students as groups and apply their lessons as usual without satisfying most of its aims and components. There are many other problems, like crowded classrooms, the furniture, the available instruments and equipment and many other things so most teachers were afraid to apply this method in teaching and tried to use the traditional methods. The Educational Training and Developing Department in the Ministry of Education in Jordan concentrated in their training courses on teaching the new curriculum and identified several teaching strategies which use critical thinking in the classroom, like problem solving through discovery and questioning, social inquiry, value inquiry, the scientific method, discovery learning and creative thinking (Ministry of Education – Jordan, 1993). In addition, in their training courses they referred to the need to use cooperative learning and spoke generally about it and about its effectiveness. Hence, there was a need for such research to assess the effectiveness of cooperative learning strategies versus traditional teaching methods as a new treatment method for students who have difficulties with mathematics. In addition, it was necessary to explore empirically the rationality to use this instructional method and illustrate how it might contribute to enhance students' mathematical achievement and promote their problem solving skills; in other words, to examine the rationality to apply cooperative learning in Jordanian mathematics classroom and how it might improve the quality of teaching and learning process.

Actually, cooperative learning takes little place in some schools in Jordan and then just for the first four primary stages (1 – 4 years). During visits to schools as supervisor for student teachers, the author noted that this strategy in instruction is not implemented in a correct way. Teachers in Jordan have limited experience and knowledge of how to teach groups cooperatively and how to benefit from this strategy in teaching (Lafi, 2001). The only difference in teaching when cooperative methods are supposedly being applied is that small groups, usually of 5 -6 students, sit around a table and inter-act but, apart from this, the strategy for learning is no different from traditional methods. Although the author has heard from many teachers that they are interested in using cooperative methods, there is little evidence of its actual application. This would include individual accountability, group goals, task support and social skill developments. Davidson (1990a) points out that the effects of cooperative learning on mathematics skills were definitely positive when there was a combination of individual accountability and some form of group recognition for high performance. The effects of small-group learning were non-negative (that is, not significantly different from traditional instruction) if the teacher had no previous experience in small group learning, was not aware of well-established methods and did very little to accelerate group cooperation or interdependence. Therefore, the study provided teachers with a training programme in how to use cooperative learning strategies in the mathematics classroom in order to provide them with a basic framework for effective implementation. The study searched to find how teachers can best be trained to use cooperative learning in mathematics and what the key skills are of the teachers in implementation.

- **The Possibilities for Enhancing Positive Outcomes in the Non-Cognitive Domain through Cooperative Learning**

Classes mainly contain students from different levels of ability. Mixed ability classes include low, middle and high achieving students where success may be easy for some of them and difficult for others. Moreover, some of students may have difficulties in learning and improving new mathematical skills because of their previous mathematical weaknesses and difficulties. Traditional teaching methods may not be the solution for some students who, even if they get a feel for the new knowledge, still find that they are at the bottom of the class. This feeling may cause some form of anti-social behaviour (Slavin, 1990a). Therefore, teachers must try to avoid the problems that arise in such traditional classes by encouraging students to help one another learn and join together to succeed academically through working cooperatively. Davidson

(1990a) found that small groups provide a "social support mechanism" for mathematical learning. Students have a chance of exchanging ideas, asking questions, explaining, discussing and simplifying ideas and concepts with each other which helps them to understand the ideas in a meaningful way and, hence, express feelings about their learning. This is part of the social dimension of learning mathematics. Joyce, Showers and Bennet (1987) also reported that the cooperative environment has substantial effects on the cooperative behaviour of the students, increasing feelings of empathy for others, reducing inter-group tensions and ethnic sensitivities. This study examined the rationality for using cooperative learning strategies in such mixed ability classes and how it may have an affect on students' outcomes in different cognitive and non-cognitive domains that may increase their aptitude to learn and, hence, enhance achievement.

- **Negative Attitudes towards Mathematics**

Unfortunately, despite the importance of mathematics, most students grow to dislike the subject. Davidson (1990a) shows that many students and adults are afraid of mathematics or, it could be said, they are troubled by "math avoidance or math anxiety". Actually, most of them often believe that only a few excellent individuals can challenge mathematical problems and solve them successfully. However, it is understandable that having students use their mathematics skills is expected when positive attitudes toward mathematics have been built (Charles and Lester, 1984). This study was concerned in its investigation with the effect of using cooperative learning strategies versus traditional ones in students' attitudes toward mathematics.

All that has been outlined in the previous brief topics and problems are among the most significant in teaching mathematics and have lead to a rethink of strategies for learning. The basic research assumption in this present study revealed that cooperative learning strategies may be a suitable solution to most of these problems.

This present study provided teachers in the cooperative experimental group with in-service training programmes with a developmental framework about cooperative learning and how to use it in the mathematics classroom. It compares the effectiveness of applying cooperative learning strategies versus the traditional ones that are usually used. It searches for a major aim about the students' progress in mathematical achievement and problem solving skills. It analyses the views of teachers and students about the use of this new teaching method versus the traditional ones. In addition, this study investigates other outcomes which might be achieved, such as students' attitudes toward mathematics and students' social behaviour as minor objectives. All these aims assess the rationality for using cooperative learning versus traditional ones in the mathematics classroom.

1.2 Aims of the Study and Research Questions

In the light of the previous issues, and since there is a considerable interest at the moment in aiming to improve the problem solving skills of students in mathematics in schools, this present research had been designed, carried out and studied in actual Jordanian classrooms during two scholastic semesters.

This study concentrates on assessing the effects of teaching approaches, especially the new teaching approach, cooperative learning, versus the traditional teaching methods, which are usually used in Jordanian mathematics classrooms. The basic aim is to assess the effectiveness of cooperative learning in promoting problem solving skills and achievement in mathematics within the content of other factors which may affect the teaching and learning process. So, the researcher took care to choose teachers who have the same qualifications and approximately the same number of years of experience. In addition, the students were from the same grade, were approximately the same age and the same curriculum was covered within the period of the study in all classes. The study considered the effect of other external factors that might play a role in the teaching and learning process, such as gender differences, students' ability, teachers' and teaching skills, the type of the material within the curriculum and, to some extent, the social class. The study also investigated the rationality for using cooperative learning in the mathematics classroom; it analyses the views of teachers and students on the use of cooperative learning and how it might contribute to the broader development of the students. The study used empirical research that took the form of professional development for teachers where a training programme had been conducted for those teachers who applied cooperative learning strategies. So, this study investigates how teachers can best be trained to use cooperative learning in mathematics classroom and what the key skills are in implementation. Finally, the study advances several recommendations in the light of the present research to develop cooperative learning in mathematics as a special aim, which may lead to improving the teaching and learning process in mathematical education.

In summary, this present study aims to:

- examine the rationality for using cooperative learning in mathematics
- assess the effectiveness of cooperative learning versus traditional ones in promoting problem solving skills and achievement in mathematics
- investigate how teachers should best be trained to use cooperative learning strategies and explore how these strategies may be applied most effectively
- analyse the views of students on the use of cooperative learning strategies
- analyse the views of teachers on the use of cooperative learning strategies
- improve the use of cooperative learning in the mathematics classroom
- evaluate the general developmental progress of students involved in the experiment.

To fulfil the aims of the study, the following research questions were determined.

- Should we consider cooperative learning as a rational strategy in mathematics teaching and, if so, why?
- How effective is cooperative learning in promoting problem solving skills and other achievements in mathematics?
- How can teachers best be trained to use cooperative learning in mathematics and what are the key skills of the teachers in implementation?
- What are the students' views of the use of cooperative learning and traditional methods in the mathematics classroom?
- What are the teachers' views of the use of cooperative learning and traditional methods in the mathematics classroom?
- What recommendations may be advanced from this study to improve cooperative learning in mathematics?
- In what ways might cooperative learning contribute to the broader development of the students?

In order to achieve the previous objectives and to answer the research questions, the researcher followed an experimental research study in the actual classroom setting because it is the real place in which teachers and students interact together within the teaching and learning process. The study sample was composed of 348 eighth grade students in eight classes from two separate female and male schools with their eight female and male teachers. Four female and male teachers were trained in how to use cooperative learning strategies in their classes during the implementation of the experiment, while the other four teachers had been asked to keep using their traditional teaching methods. The experiment took place within two scholastic semesters and the same mathematical contents were covered by both experimental groups. This research employed the quantitative-qualitative triangulation to provide an illustration of the quantitative data. To measure the general progress in students' mathematical performance and problem solving skills a pre-test and a post-test were designed and tested. Tests measured: a) comprehension and understanding, b) application and problem solving and, hence, the types of the questions were of the standard of; a) knowledge, computations and comprehension, b) application and analysis. In addition, a self-evaluation programme evaluation questionnaire for all students in the experiment had been designed. This questionnaire searched for five basic parts in the study. First of all, it evaluated students' perspectives about the effectiveness of teaching strategies in their mathematical achievement and problem solving skills. The second part of the questionnaire was to look at the students' views about the teaching methods applied. The next part was to explore the attitudes of the students toward mathematics. The fourth part of the questionnaire was to search for other advantages which were expected from applying cooperative learning other than achievement. The last part searched for some external factors that may play a role in the learning process.

Another research instrument used in this study was a general weekly progress diary that was completed by the teachers themselves during the period of the study. An observation sheet was completed by the researcher during the class visits to evaluate the teachers' teaching skills in both traditional and cooperative teaching methods.

A syllabus for training teachers in how to use cooperative learning strategies in the mathematics classroom had been prepared for use during the teachers' training programme. The researcher developed the model of implementation which was a mix of different cooperative learning strategies in order to improve the quality of the implementation in such a way to be unique and suitable to be applied in the Jordanian mathematics classes. It had been prepared according to the basic components which must be included in cooperative learning and related to basic roles and techniques, which will be discussed in chapter five, in order to apply cooperative learning in a correct way to achieve its effectiveness. This syllabus identified the definition of cooperative learning for the teachers and the rationality for using it in the mathematics classroom. It clarified the principle components in cooperative learning and when to use this method in the mathematics classroom. This syllabus also denoted the teachers' role and decisions in cooperative learning and explained how to start the implementation and how to teach problem-solving lessons by using cooperative learning strategies. In addition, it discussed, for the teachers, how to adapt a mathematics lesson for the use of cooperative learning groups by giving some samples of activities and lessons that had been developed by the researcher to adapt some Jordanian mathematics lessons for the use of cooperative learning.

All teachers and some students who participated in this experimental research study and had carried out the qualitative part were interviewed. In addition, the researcher recorded observations and field notes during the class visits within the implementation of the experiment. Moreover, the teachers themselves had recorded weekly diaries during the experiment to assess their judgement about the students' progress in their mathematical ability and skills.

1.3 Limitations of the Study

This present study was carried out and implemented at the Jordanian Upper Primary Schools to examine the rationality for using cooperative learning and how it may be used in an affective way to transfer the teaching and learning operation from the teacher-centred situation into student-centred learning, in the light of the present position, including the curriculum, the qualifications of the teachers, the nature of the schools and classes and all present facilities. Moreover, this study explored the effectiveness of cooperative learning strategies in promoting students' mathematical achievement and problem solving skills versus the usual traditional teaching methods which used to be conducted in schools for the eighth upper primary stage (approximately 14 years old). This study has few limitations that may have affected the results obtained. Despite the findings of the study and the recommendations drawn from the data collecting and raised in this research, these results must not be generalised and must be kept as tentative until more extensive research evidence exists.

Although the experiment was conducted over two scholastic semesters, the time for the real implementation of the experiment was limited. This is because it takes time for good preparation to start the experiment, especially for training the teachers in how to use the new cooperative learning strategies to be applied in an affective way and for applying the pre-test. Moreover, time was spent in conducting the interviews, the questionnaire and the post-test at the end of the experiment. The real time of implementation for the experiment was nearly five to six months. This period of time was not enough to include all the branches of mathematics and, although most of them were included, such as equations, probabilities, some subjects in geometry, algebra, and trigonometric functions, it did not include other branches, such as statistics, measurements, functions and numbers. This was because the curriculum in Jordan is fixed and must be covered in a specific time. It could be possible that other results may be obtained when applying the experiment in other branches of mathematics. Although the researcher did her best in the training programme for teachers, and because this method was a new one in implementation, more experience and development would be expected of the teachers' skills if the implementation had taken more time. Moreover, the time might not have been enough to gain other expected outcomes, especially in the non-cognitive domain and attitudes that may need a long time to have an effect on students' beliefs, feelings and behaviour.

Another limitation considered of this study is that the teachers who conducted the experiment had the same qualifications and approximately the same number of years of experience. Other results may be raised if teachers with different qualifications or experiences were used. Also, the students involved were from the same grade and approximately the same age. Different results may be generated with students in other grades or in different ages. Actually, the best sample would be that which could cover all over the world. However, it is the nature of research anywhere to deal with just a sample for the study, so it has its limitations.

1.4 Contents of the Study

This chapter is an introduction to the present study which highlights the research aims to be achieved and the questions to be answered. The next five chapters establish the context of the study and review the literature that is needed to construct the theoretical framework for research construction and practice.

Chapter two represents the Jordanian Educational System as a setting for the study. It includes the Jordanian Educational Developmental Plan and its objectives. This chapter also represents mathematics as a subject in the Jordanian Educational System.

Chapter three highlights general principles in mathematics education. Within this chapter, the researcher clarifies the philosophy of mathematical education, the nature and structure of mathematics, mathematical learning, the aims and objectives of mathematical education, mathematical construction and problem solving skills. In addition, general mathematical teaching strategies are represented and, finally, the traditional teaching methods that used to be conducted are highlighted.

In chapter four "cooperative learning", several headings are highlighted and discussed, such as, cooperative learning in history, the meaning of cooperative learning, cooperative learning methods, how cooperative learning can be effective and the outcomes of cooperative learning.

Chapter five is a continuous link to the previous one and discusses the use of cooperative learning in the mathematics classroom. In this chapter the researcher provides the reader with the best framework for using cooperative learning in the mathematics classroom, from the first steps of informing teachers of the best definition of the cooperative learning through the explanation to answer the following questions: Why use cooperative learning in the mathematics classroom? What are the principle components of cooperative learning? When should cooperative learning be used in the mathematics classroom? What are the teacher's roles? What are the teacher's decisions? How should cooperative learning be started to be implemented? How should cooperative problem solving lessons be taught? How should a mathematics lesson be adapted for use by cooperative learning groups?

Since this research is considered classroom research, chapter six addresses perspectives on mathematics classroom research. In this chapter the research highlights the factors which influence the teaching and learning process. Moreover, this chapter discusses how to design, implement and evaluate an experimental research study as a base to construct the methodology adapted in this present study, which is displayed in detail in chapter seven.

Within the contents of chapter seven, the researcher details the methodology followed in this present study including: the design of the study, variables of the study, the time scale of the fieldwork, the research questions, the null hypotheses of the study, the research instruments development and, finally, the procedure of the study.

In chapter eight the researcher represents in detail the quantitative and qualitative data analysis with a discussion of all issues that had been assessed and investigated within this research, including: assessing the effects of teaching method (the cooperative versus the traditional one) in promoting problem solving skills and achievement in mathematics, analysing the views of the students and teachers on the use of the cooperative learning versus the traditional methods in the teaching of mathematics, students' attitudes toward mathematics, outcomes other than achievement, the external factors that might affect the learning and teaching process, evaluating the training programme and the teachers' response towards it, evaluating the teaching skills in the traditional classrooms and how well the teachers in the traditional classroom apply the teaching method. Finally, the general developmental progress of students involved the experiment is evaluated.

The last chapter highlights the conclusion, the uniqueness of the study, the implications of the study for theory and practice with recommendations and advances further recommendations in the light of this study in order to participate in developing the teaching and learning process in the mathematics classroom.

The list of the references is presented at the end of this dissertation and it is followed by the appendices used within this research.

Chapter Two

The Jordanian Educational System in the Light of the Study

Chapter Two

The Jordanian Educational System in the Light of the Study

2. Introduction

Jordan is considered one of the countries that is still in its developing stages in several fields, including the educational field. In recent years a considerable interest has been shown in the Jordanian educational system to improve the educational outcomes in different domains. Hence, the Educational Developmental Plan (1989-1998) emerged to promote the standard of general educational outputs and to implement the international development. This plan has the scope to be achieved and programmes to be implemented. The contents of this chapter highlight the Jordanian Educational Developmental Plan in the light of the study and how this research might achieve the objects of this developmental plan and its programmes.

Since this present study presents mathematics classroom research that had been conducted in Jordanian schools, the researcher introduces mathematics as a subject in the Jordanian Educational System within the contents of this chapter. Moreover, she highlights the mathematical curriculum with its main headings and objectives for the need of the study.

2.1 The Jordanian Educational Developmental Plan and its Objectives

The objectives of Jordanian education have changed each decade for the past forty years. In the decade of the sixties (1960-1969) the basic objectives of the educational system concentrated on achieving compulsory education in Jordan. However, in the 1970s the aims were directed to divide the educational fields into academic and vocational ones for the purpose of serving and improving the society. The 1980s concentrated on enhancing the quality of education and evaluating its inputs and outputs but the 1990s was hoped to be the decade of comprehensive educational improvement, which would take care of all the ingredients and elements of educational system. Hence, the Jordanian Educational Developmental Plan (1989-1998) emerged from the First National Conference on Educational Development (FNCED) (Hindawy, 1992).

The Ministry of Education in Jordan planned for the education policy and addressed this work according to basic elements: the educational philosophy, the educational objectives, the educational field, the educational elements and the educational tools (Al-Tall, 1993). According to these basic elements, the Ministry of Education planned the education developmental policy in the 1990s in order to contain all the educational ingredients, the process and its elements. These include the buildings for the kindergarten, primary and secondary stages, while taking care of teachers, schools, administration, school textbooks and curriculum, educational technology and schools activities.

The following paragraphs highlight basic issues in the Jordanian educational policy that had been discussed at the First National Conference for Educational Development which was held on 16-17 May 1987 (Ministry of Education - Jordan, 1987).

- **Jordanian General Educational Objectives**

The educational objectives emerged from the educational philosophy. In the light of this present study, the objectives concentrate on enabling the student to:

1. use mathematical thinking, numerical systems and mathematical relations in scientific fields and daily life situations
2. understand the concepts, facts, principles and theories to deal with it and use it to serve the student and to solve his problems
3. understand the technology and gain the skills in dealing with it to develop and use it in order to serve society
4. collect the information, save and recall it to use it in explaining the phenomenon, expecting different possibilities for incidents and taking decisions in all fields
5. use critical thinking and scientific ways in research and solving problems
6. appreciate humanity and form positive values towards the esteem of self and others
7. gain personal adaptability and social behavioural roles in dealing with others and with life changes.

- **Jordanian Educational Political Principles**

These are concerned with:

1. directing the educational process to develop the personality of the citizen to enable him to analyse and to participate in creating positive dialogue to build up the values from the Arabic, Islamic and human tradition
2. settling the scientific approach in the educational system, planning, carrying out, evaluating and developing the research, evaluating and following up systems.

- **Jordanian Educational Developmental Plan**

1. The general objectives:
   - improving the standard of the general educational outputs
   - interacting with the scientific and technological development
   - achieving the suitability to the present setting
   - interacting with the international cultural development.

2. The developmental fields:
   - the educational policy (including its philosophy and objectives)
   - educational structure
   - curricula and textbooks
   - educational technology
   - educational administration
   - school buildings
   - qualifying and training workers in the educational field
   - cooperating with universities.

3. The developmental stages:
   - first stage (1989- 1992)
   - second stage (1993- 1995)
   - third stage (1996- 1998).

4. Setting projects including basic reform programmes in the following fields:
   - curricula, school textbooks and educational technological programmes
   - schools buildings

- qualifying and training teachers and workers in the educational field
- planning, research and development in the educational field.

5. Other educational programmes:
   - educational structure, including:
     a) pre-school education for two years (ages 4-6)
     b) primary education for ten years (ages 6-16)
     c) secondary education for two years (ages 16-18)
   - informal education
   - examinations and educational evaluation
   - educational activities and teachers' clubs
   - educational guidance
   - educational technology
   - educational administration and schools administration.

The Jordanian Educational Development Plan (1989-1998) is a comprehensive plan with its scope and programmes. The aims are to promote the standard of the general educational outputs (achievement and performance), work together with the scientific and technological development and to interact with the international cultural development. The programmes concentrated on school textbooks and curriculum, the educational technology, school buildings, the educational facilities professional development and training and, finally, the educational planning, researching and developing programmes. The purpose of these programmes is to qualify teachers scientifically, behaviourally and educationally to higher degree standard and train them in order to work together with the educational development needs in curriculum and in teaching methods, also, to encourage self-discipline, creation, innovation and applied learning. Some programmes try to cooperate with the Educational Research Centres in the Jordanian Universities and with the National Centre for Research and Educational Development to benefit from the outcomes of the scientific and educational research. (Ministry of Education – Jordan, 1987, 1988).

This study meets some of these objectives. The basic aim of such research is to assess its effectiveness as a developmental method on the quality of learning especially in promoting mathematical achievement and problem solving skills;

hence, to try to achieve basic objective in the educational developmental plan which is enhancing students' problem solving skills. In addition to that, this study assesses the advantages and disadvantages of cooperative learning and the possibility to apply it in a correct way in order to gain the exposed outcomes in the academic field, particularly, in problem solving skills in mathematics and other social and behaviour outcomes.

This study participates in an experimental methodology in Jordanian schools to serve one of the most important subjects in Jordanian Educational System, mathematics, by applying a training course for some mathematics teachers using cooperative learning in the mathematics classroom. In addition, an experiment was conducted with a sample of our male and female students in the upper primary stages, especially students in grade eight (approximately 14 years old) as developmental educational research.

This research plays a major role to achieve some objectives related to the Jordanian general educational objectives, Jordanian educational political Principles and the Jordanian Educational Developmental Plan. These have been mentioned previously.

2.2 Mathematics in the Jordanian Educational System

The educational structure in Jordan consists of different stages of school provision. The first stage, which begins before the primary stage is the kindergarten which is not compulsory and is run by the private sector and supervised by the Ministry of Education. The primary stage is the compulsory one which extends for ten years from six to sixteen years old. The secondary stage, which is not also compulsory, extends for two years (16-18 years old) with some specialisation in the field of the general secondary certificate which is gained by the students when they pass the General Certificate of Secondary Examination.

Mathematics is one of the most important subjects in the Jordanian curriculum and is taught at all stages, both the compulsory and the non-compulsory ones. In the last ten years, many changes and developments in the mathematics curriculum have been made in all stages to meet the needs of applied mathematics and according to the objectives of the Jordanian Educational System that had been addressed by the First

National Conference for Educational Development, the National Team for Mathematics built up the general objectives for the mathematics curriculum. This team also took care of other Arabic and foreign experiences in the field of mathematics curriculum to determine the concepts of the Jordanian mathematical curriculum at different stages and divided them into eight basic concepts (Ministry of Education (The National Team for Mathematics) 1989):

1. numbers
2. mathematical principles and their applications
3. geometry
4. measuring
5. algebra
6. triangles
7. arithmetic
8. statistics and probability.

The previous basic concepts are determined in the mathematics curriculum for the compulsory primary stage on 31/8/1988 (Ministry of Education- Jordan (The National Team for Mathematics), 1989). The National Team for Mathematics set the general aims for each different grade of the ten grades of the primary stage. According to these general aims, they built up the mathematical contexts for each grade in different units and set their specific sub-aims. These include the specific aims, the context, the tools, teaching methods and the activities. The mathematical context has been divided into five categories:

1. concepts and terminology
2. symbols
3. rules and generalisations
4. skills and algorithms
5. problems.

The last category, problems, is very important and was characterised as a separate one because of its importance in promoting the students' ability to solve problems in their daily life situations.

The curricula include the procedures, methods and activities in order to help the teachers and guide them to some methods and techniques that may be used in teaching. In addition, the curricula present some of the evaluation procedures to examine the students' performance correctly and to measure to what extent the aims have been satisfied. These curricula concentrate on major points, for example:

- concentrating on computational skills, and geometric and algebraic application
- making a balance between the concepts and the mathematical skills
- concentrating on problem solving and proving methods.

The main headings for the mathematics curriculum in the primary educational stage

The National Team for Mathematics built up these seven headings regarding the general objectives of the primary educational stage. It includes seven lines, each one of them related to one of the basic lines in the primary educational stage. Moreover, these headings relate to the mathematical construction: concepts, rules and generalisations, procedures and algorithms and, finally, problem solving (Ministry of Education- Jordan (The National Team for Mathematics), 1989). The following paragraphs describe the seven headings.

- **The basics of the mathematics curriculum**

The National Team for Mathematics built the mathematics curriculum regarding four basics: philosophy, social, psychology and knowledge.

- **The elements of the mathematics curriculum**

In order to build the mathematics curriculum to be comprehensive and integrative, all the elements that satisfy the expected aims were included. These curricula contain basic four elements: the aims, the context, the methods, procedures and activities and, finally, the evaluation methods.

- **The aims of the mathematics curriculum**

  - **General aims**

The mathematics curriculum in the primary stage tries to achieve the following general aims in different fields.

1. In the field of mathematical concepts and information:
   - providing students with the basic mathematical knowledge that is necessary in different fields of knowledge
   - developing students' understanding for the nature of mathematics
   - increasing students' understanding about the surroundings in which they live
   - acquainting students with the language of mathematics, its characteristics and how to use it
   - acquainting students with measurements systems especially the metric system.

2. In the field of mathematical skills:
   - providing students with essential skills in mathematics that are necessary in daily life situations
   - developing students' skills in mental computations
   - using the language of mathematics to express life situations
   - gaining skills in categorising data, representing it graphically, reading and explaining it
   - representing mathematical relations graphically
   - using different measurements tools.

3. In the field of developing mathematical thinking techniques and solving problems:
   - using the scientific styles in thinking through the following methods:
   a) using logical proving ways to generalise mathematical rules from given assumptions
   b) learning mathematical problem solving steps and how to use them
   c) applying mathematical problem solving steps in solving daily problems
   d) examining the solutions and their rationality
   e) using logical thinking in taking decisions

   - discovering the symmetry and the differences between mathematical patterns and relationships
   - using relationships between geometric shapes in two and three dimensions to solve daily life problems.

4. In the field of attitudes toward mathematics:
    - grasping the role of the mathematical knowledge and its development
    - tasting the beauty of mathematics
    - building positive attitudes toward mathematics and mathematicians
    - improving positing self-esteem through mathematical situations like proving and solving mathematical problems
    - appreciating the role of scientists who participate in developing mathematics.

In order to achieve these general aims, it is very important to achieve specific aims in the following domains.

1. In the cognitive domain:
    - communication aims (related to the first general aim, p. 25)
    - basic mathematical skills' aims (related to the second general aim, p.25).
    - mathematical thinking aims(related to the third general aim, p.25)
2. In the affective domain:
    - affective aims (related to the fourth general aim, p. 26).

- **The basic concepts of the mathematics curriculum**

According to the general and specific aims of the mathematics curriculum, the National Team for Mathematics put the specific concepts of the mathematics curriculum: numbers and operations on it, mathematical principles and their applications, geometry, measuring, algebra, triangles, arithmetic, and statistics and probability.

- **General guidelines in teaching methods and evaluation**

In the light of previous research findings related to the learning and teaching of mathematics, the recommendations concentrated on the following issues.

1. Teaching methods guidelines:
    - learning by directed discovery
    - using different activities
    - linking between the concepts, skills, and laws of mathematics and the real life situation for students

- highlighting the mathematical construction: concepts, rules and generalisations, procedures and algorithms and, finally, problem solving
- adapting to the individual differences
- providing students with feedback.

2. Evaluation guidelines:
   - evaluating students' knowledge and skills in mathematics
   - evaluating the concepts, laws, procedures and mathematical problems
   - using different evaluation methods
   - using comprehensive, continuous and valid evaluation processes.

- **The instruments for implementing the mathematics curriculum**

In addition to the teachers' role for implementing the mathematics curriculum to achieve its objectives, the following instruments help teachers towards good implementation:

- students' text book
- teacher's guide
- educational television and recording machines
- educational computer
- educational tools.

- **Evaluating and developing the mathematics curriculum**

This aim can be achieved with the assistance of all workers in the educational field especially mathematics teachers and supervisors. This can be achieved by giving their comments, advice and recommendations.

A very important issue here is how to apply the mathematics lessons and what the teaching methods are which must be used in order to develop the students' ability and to promote their skills, particularly solving problems.

2.3 Conclusions for Research Construction

This chapter has reviewed the Jordanian Educational Developmental Plan and its objectives. Moreover, it has presented mathematics in the Jordanian educational system to give useful insights into building research that is designed to achieve most of these aims in several and different fields.

1. Providing in-service training programme to train teachers in how to use new teaching methods, for example, cooperative learning.
2. Assessing the effectiveness of applying cooperative learning strategies in improving the quality of learning, which is one of the basic aims of this developmental plan, especially in promoting problem solving skills in mathematics.
3. Exploring the rationality of using cooperative learning strategies in Jordanian upper primary mathematical classes and how it might broaden the development of students in different cognitive and affective domains as basic aims in the Jordanian mathematical educational system.

Chapter Three

General Principles in Mathematics Education

Chapter Three
General Principles in Mathematics Education

3. Introduction

Ernest (1991) in his book *' The Philosophy of Mathematics Education '* identified four foundation issues and problems for the philosophy of mathematics education: philosophy of mathematics, the nature of learning, the aims of education and the nature of teaching.

The philosophy of mathematics education forms a setting for this present study in the mathematics classroom to investigate how the nature of teaching might affect the nature of learning in the mathematics classroom to achieve the aims of mathematics education, where all of these issues are considered the basic co-ordination for the philosophy of mathematics education.

The study assesses how teaching methods and strategies might affect the learning process. Particularly, the study assesses the effectiveness of cooperative learning strategies versus traditional teaching methods on promoting students' mathematical achievement and their problem solving skills. On the other hand, it evaluates the teachers' general teaching skills in both cooperative and traditional classes. All of these aims are designed to develop the teaching and learning process in mathematics and to enhance students' outcomes in a way that will achieve the aims of the mathematical education. So, it is worthwhile in such research to speak about the real meaning of mathematics, the structure and learning of mathematics, the aims and objectives of mathematics education, mathematical construction and problem solving skills, the general teaching strategies in mathematics and the traditional teaching methods. This chapter highlights these issues to give enough background for an effective research study.

3.1 The Nature and Philosophy of Mathematics

Mathematics is an abstract science that is created by the human brain and only exists in the human mind or in written form (Quirk, 2002). Mathematics is concerned with all the ideas, methods and kinds of thinking. It is not just dealing with traditional branches like computations and numbers, algebra (the language of symbols and relations), geometry (the study of shapes, volumes and space), triangles, statistics, integrating and differentiation that, until very recently, were still considered forms of mathematical science. Nowadays, mathematics skills, according to the modern theory, are more than that. Abu-Zena (1997) regarded mathematics in the following ways.

1. Mathematics is a method and a pattern in thinking that organises the logical proof and decides the probability to agree specific assumptions.
2. Mathematics is a language that uses specific and certain symbols and expressions in order to facilitate the communicating thinking between people. It is described as an international language with its expressions and symbols, known to people all over the world.
3. Mathematics is a well-ordered knowledge with its structure that has its origins, arrangements, and its series starting with undefined terms then by defined ones and after that its postulations and assumptions and, finally, with its theories and generalisations.
4. Mathematics involves studying patterns which means the sequence and continuity in numbers, shapes and symbols, and it provides us with models for life and materialistic situations and forms part of the materialistic surroundings that we live in.
5. Finally, mathematics is considered as an art. The beauty of mathematics is hidden by its co-ordination and its ideas. Even the mathematician is considered as an artist who generates mathematical ideas and knowledge that reflect the mathematician's creative instincts and his/her ability to imagine.

Ernest (1991) identified that mathematics is that which is done and has been done for the last four thousand years by the mathematicians and knowledge of the nature of mathematics lies in an ability to do it. Moreover, he commented that the philosophy of mathematics does not only mean knowing what mathematics is, but it is a reflection upon mathematics, particularly its own questions and answers. It is a general account of mathematics, how its nature can be accounted for and how it is that human beings are able to do mathematics. He added, speaking about the philosophy of mathematics focusing on teachers' personal conceptions of nature of mathematics, that the way that mathematics is taught and the underlying philosophy of mathematics may affect the curriculum developments (Ernest, 1991).

3.2 The Structure of Mathematics

The structure of mathematics is built on axioms and it is started by undefined terms and expressions. These terms and expressions are related to mathematical statements which are called assumptions and axioms and, by using the role of the assumption logic, approved mathematical statements are created, which form theorems. These terms explain the characterisation of the unknown and the known terms and also explain the characteristics of the principal element and its basic specifications. In order to build this structure of mathematics, the mathematicians give specific characteristics to these axioms, like consistency, independence and completeness (Abu-Zena, 1997). Ernest (1991) also defined mathematical knowledge as a set of truths, in the form of a set of propositions with proofs, and that the function of the philosophy of mathematics is to provide certain foundations of this knowledge.

3.3 The Learning of Mathematics

Before giving a definition of learning the most progressive theory within education will be discussed; that is the theory of learning mathematics. This theory involves the students' creative knowledge and artifacts, students' response towards the environment and seeking out relationships. Learning involves investigating, exploring, discovery, play, discussion, undertaking projects, activities and cooperative work where the environment is rich, challenging and enough to build self confidence, positive attitudes and good feelings (Ernest, 1991). This present study assesses the rationality for using cooperative learning as an instructional method in the mathematics classroom that may be a suitable learning environment to involve most components of the theory of learning mathematics.

The following simple definition of learning is given by Weissglass (1976, p. 16).

> " Learning consists of evaluating new information in relation to information that's already understood and sorting it in a form that's available for use in new situations".

Marshal (1992, P. 6) defined learning and stated

> " Learning is generally defined as the passive acquisition of facts, skills, and concepts often through drill and guided practice, reward, and punishments ".

Also, Abu-Zena (1997) defined the general readiness for learning to be the ability of the child to reach the necessary standard from the physiological, affective and social maturity that allows him/her to enter the school. He also defined the readiness for learning as the ability of the learner to learn something or to gain information or skills after a period of training to prepare him to learn new things. This readiness is related to two factors: maturity and previous experience.

Bloom analysed the objectives of education and classified them into three domains: cognitive, affective and the psychomotor. The first attempt of Bloom was to classify the objectives related to thinking into two major parts. The first one related to gaining knowledge and information. The second one dealt with developing the skills and abilities needed to use such knowledge and information. He also classified the standards of educational objectives in the cognitive domain into six standards. The first standard is knowledge. The second one is the comprehension that is presented by translation, interpretation and extrapolation. The third standard is application. The next one is analysis. Then comes synthesis and the last one is evaluation (Morris and Fitz-Gibbon, 1978a). In learning mathematics there was also specific research. For example, Orton (1992, P. 24) summarised some educational research and stated:

> " Skemp (1971) discussed the process which needs to be adopted in doing mathematics. Polya (1945) attempted to analyze the process of solving mathematical problems, a theme subsequently taken up by Wickelgren (1974). Brown (1978) suggested that there were four types of mathematical learning, namely simple recall, algorithmic learning, conceptual learning, and problem solving. Her Majesty's Inspectorate (1985) listed five main categories of objectives for mathematics learning, and these were facts, skills, conceptual structures, general strategies and personal qualities."

Learning new subjects in mathematics involves passing through four stages, namely, understanding, assimilation, transfer and permanence. (Abu-Zena, 1997). The last steps in learning mathematics are very important in order to enable the student to master learning to develop his/her skills and to enable them to understand the mathematical meaning of a new concept or a new regulation and after that they need to do it by themselves in order to assimilate their understanding to become a part of their mathematical background. Also, it is to enable them to use this concept or regulation in the future and in different situations. Students must understand its general abstract in order to grasp the suitable situations in which to apply this concept or this regulation.

3.4 Aims and Objectives of Mathematics Education

Ernest (1991, p. 191) stated that

> " The mathematical aim of the progressive educator is to contribute to the overall development of the growing human being, to develop the child's creativity and self realisation through the experience of learning mathematics. This involves two things. First, the development of the child as an autonomous inquirer and knower in mathematics. Second, the fostering of the child's confidence, positive attitudes and self-esteem with regard to mathematics, and shielding the child from negative experiences which might undermine these attitudes."

The aims of mathematics form the base to build the mathematics curriculum. These aims must include the general aims of education, together with the specific aims in mathematics as a basic subject, to provide students with the opportunity to explore their own understanding of mathematics, as graduates in the subject, in such a way that their knowledge will enable them to invest fully in the opportunities required at school level mathematics and enable them also to use it in their life to achieve its effects in different fields (Wain and Woodrow, 1980). It is difficult, really, to point out all the aims and objectives of mathematics education. The National Team for Mathematics in Jordan identified some of these basic aims (Ministry of Education – Jordan (The National Team for Mathematics), 1989), which include enabling the student to:

1. know the language of mathematics and its properties
2. use the language of mathematics to express his/her ideas and pass it on to others in an accurate and clear way
3. develop his/her understanding of the nature of mathematics
4. improve his/her ability in logical thinking and mathematical proof to use them in understanding and solving problems

5. use new and different methods in collecting information and ideas, arranging and presenting them as statistical data and operations maps, etc.
6. increase his/her understanding of the materialistic environment through his/her studying of mathematical models, geometric shapes and mathematical rules and regulations
7. develop his/her skills in calculation by using several methods to add to his/her skills in accuracy, understanding and efficiency
8. gain knowledge of mathematical information and necessary skills to study other branches of science
9. gain practical attitudes in his/her thinking to face problems and to choose suitable solutions to them
10. develop him/her taste for the beauty and symmetry of geometric shapes and mathematical constructs
11. build motivation to continue his/her studying and learning of mathematics
12. develop his/her ability for self-learning
13. gain the mathematical knowledge that is necessary to continue his/her study in the future in any specialisation he/she chooses.

Her Majesty's Inspectorate (1985, pp. 2-6) addressed some of the aims of mathematics teaching:

> " **1. The aims of mathematics teaching**.
> **1.1** There are important aims, which should be an essential part of any general statement of intent for the teaching of mathematics. Those stated in this chapter are considered to be indispensable but it is recognised that there may be others which teachers will wish to add. These aims are intended for all pupils although the way they are implemented will vary according to their ages and abilities.
> **1.2 Mathematics as an essential element of communication.**
> **1.3 Mathematics as a powerful tool.**
> **1.4 Appreciation of relationships within mathematics.**
> **1.5 Awareness of the fascination of mathematics.**
> **1.6 Imagination, initiative and flexibility of mind in mathematics.**
> **1.7 Working in a systematic way.**
> **1.8 Working independently.**
> **1.9 Working cooperatively.**

1.10 In-depth study of mathematics.
1.11 Pupils' confidence in their mathematical abilities."

The National Council of Teachers of Mathematics (NCTM) (1989, p.5) defines five general aims of teaching mathematics for all students:

> " 1. that they learn to value mathematics, 2. that they become confident in their ability to do mathematics, 3. that they become mathematical problem solvers, 4. that they learn to communicate mathematically, and 5. that they learn to reason mathematically."

This present study assesses the general developmental progress for students due to applying cooperative learning in the mathematics classroom to achieve the aims of mathematics education and how it might help to promote their mathematical achievement, especially in solving problems.

3.5 Mathematical Construction and Problem Solving Skills

Mathematical construction consists of concepts, rules and generalisations, skills and algorithms and, finally, problem solving. This scientific classification is applicable in the field of arranging the mathematics context curriculum. Even more, it is a practical classification in the field of mathematics teaching and in the teaching aims for all standards and stages.

- **Concepts**

It was difficult to find a specific definition for the concepts as there were many attempts to define it. Love and Tahta (1991, p. 254) commented that

> "The use of the noun carries with it a tendency to think of a concept as something which can be formed, made concrete, embodied in objects."

Abu-Zena (1997) defined the mathematical concept as group of things that are comprehended or events that may be classified together on a base of combined characteristics and it may be denoted by a specific symbol or term.

- **Rules and Generalisations**

The mathematical generalisation is a mathematical statement applied to a group of things. It may be defined as an informing statement which determines a relationship between two or more concepts. Most mathematical generalisations are mathematical statements that are proved or discovered and some of them are postulates, which are taken without proof (Abu-Zena, 1997).

- **Skills and Algorithms**

Mathematical skills and algorithms are kinds of mathematical knowledge related to the ability to do some thing. For example, when the student learns how to divide a number that consists of three or four digits with another one, or when he/she learns how to multiply an algebraic expression by another one, these are called skills. When the student adopts these skills by using specific methods that is called procedures or algorithms. The algorithm is defined as a routine way to do some thing, whereas skill is defined as how to do something in an accurate and speedy way.

Learning mathematical skills is a major role in teaching mathematics and, if the student does not develop his/her skills in doing some mathematical operations and does not gain some skills, this will delay his/her learning in mathematics. Most people, especially students' parents, consider that the learning of mathematics is gaining the basic mathematical skills, especially in the fields of numbers and algebraic and geometric operations. Nowadays most teachers and parents complain because of the inability of the students to acquire these basic skills and they present some causes of this weakness.

1. Carelessness in using these skills, especially with the appearance of the calculator.
2. Using unsuitable teaching methods in teaching these skills that do not motivate students to master such skills.
3. The lack of interest and readiness to use mathematical numbers and symbols and other mathematical abstract concepts to gain the necessary skills.

Teaching mathematical skills is a very important and necessary issue.

1. Gaining mathematical skills helps the learner to understand the concepts of mathematics and offers him/her a better opportunity to direct his/her thinking in depth in problems and situations that he/she will face.
2. Gaining skills facilitates daily life at home, at work, even in dealing with others and, also, it increases a person's ability to undertake several activities.

3. Mastering skills gives the learner the opportunity to direct his/her thinking, efforts and time in a better way and face problems and situations. Then it facilitates his/her solving problems in a scientific and correct way. It will also improve his/her ability in solving problems.
4. Mastering mathematical skills will increase the learner's mathematical knowledge and the characteristics of numbers and different operations.

- **Problem-Solving**

In recent years considerable attention has been given to the place of problem solving in mathematics and how to help the students to become problem-solvers. Orton (1992. p. 35) defined to the problem solving. He stated that

> " problem solving is now normally intended to imply a process by which the learner combines previously learned elements of knowledge, rules, techniques, skills and concepts to provide a solution to a novel situation."

Also, Charles and Lester (1984) defined a problem as a task for which

> " 1. the person confronting it wants or needs to find a solution. 2. the person has no readily available procedure for finding the solution. 3. the person must make an attempt to find a solution."

It is accepted that mathematics is both a product and a process: both an organised body of knowledge and a creative activity in which the learner participates. (Orton,1992).

This research defines 'problem-solving' as a process in which the students demonstrate ability to use their mathematical knowledge (including concepts, rules and generalisations, algorithms and skills) to solve new problems presented to them in a way other than that in which it was learned. Hence, problem-solving questions present situations which do not involve the routine application of principles; that is, neither the solution itself nor the method of solution is immediately obvious from the content of the learning which has taken place. Problem solving in this research therefore is considered as 'closed-problem-solving' where the problems to be solved are mathematical and are related to the contents of the curriculum. This is appropriate to the Jordanian educational system where student assessment and progression is related directly to achievement of subject targets established by the curriculum..

Problem-solving of this nature nevertheless requires mastery of several mathematical skills which in themselves reflect student ability to understand and apply mathematics (Abu-Zena, 1997). These may be summarised as including:

- understanding the nature of the problem
- evaluating information provided
- determining the details of the question
- recalling relevant mathematical information (including concepts, rules, strategies and algorithms)
- using selected appropriate mathematical concepts, rules, strategies or algorithms
- drawing explanatory figures or graphs (if needed)
- arriving at solutions
- checking the solutions
- sometimes additionally, translating word problems into mathematical ones.

and other kinds of skills needed to solve the problem.

Teaching mathematics is a very important part of the school curriculum that provides students with certain basic life skills and processes that will prepare them to be productive members of society. Also, it gives students the necessary background knowledge and skills to enable them to make career decisions consistent with their interests and abilities. Moreover, it is assumed that it should have potential for enriching students' lives in some way (Charles and Lester, 1984). Problem solving is the highest form of learning. Peterson (1992) pointed out that recent experimental research in elementary mathematics found that students who usually spend their time in solving word problems do better in tests than those who spend most of their time on computation.

There are a wide variety of mathematical problems included in the school curricula, such as drill exercise, simple translation problems, complex translation problems and puzzle problems (Charles and Lester, 1984). In order to achieve the mathematical educational aims it is important to take care in how to teach mathematical problems and how to solve them. The techniques in solving problems involve four stages, namely: understanding the problem, devising a plane, carrying out the plan and looking back (Orton, 1992). Schoenfeld (1985) discussed the knowledge and behaviour that are necessary for an adequate characterisation of mathematical problem solving performance as resources, heuristics, control and belief systems.

No one can ignore the fact that there are different factors which play a role in the learning and teaching process, such as sex, ability, social class, culture, teaching method, and so on. Charles and Lester (1984, p.10) paid some attention to the mental processes that are involved in successful problem solving and stated that

> " three sets of interacting factors are at work.
> 1. Experience factors, both environment and personal.
> 2. Affective factors, such as interest, motivation, pressure, anxiety, and so on.
> 3. Cognitive factors, such as reading ability, reasoning ability, computational skills, and so on."

Lester, Jr. (1980) identified seven factors contributing to the difficulty of solving problems.

1. Complexity of the problem statement.
2. Methods of problem presentation and representation.
3. Problem solvers' familiarity with acceptable solution procedures.
4. Misleading incorrect solution or solution procedure.
5. Difficulty in locating reachable sub-goals.
6. Constraints arising from misconceptions or misunderstanding of information given in a problem.
7. Affective factors associated with the problem solvers' reaction to the problem.

Charles and Lester (1984) commented that

> " In short, then, problem solving is an extremely complex activity that necessitates very thoughtful consideration if you expect to improve your students' abilities to attempt and succeed in solving problems ".
>
> (Charles and Lester, 1984, p.12)

It is not easy to apply problem-solving lessons; it needs many teaching skills. Charles and Lester (1984) commented that, during problem solving lessons, the teacher must carefully explore some types of problem solving experiences for students.

1. Readiness experiences for solving problems.

   The purposes of experiences at this stage are to:

   a) establish positive attitudes toward problem solving lessons

b) enhance the development of the ability to visualise mentally the key components of a problem.

2. Exploring essential problem solving strategies by
   a) practising some mathematical activities, procedures and skills
   b) monitoring students' use of these processes and skills during implementation.
3. Solving various types of problems and discussing their solutions.

Lesh (1981), Gilbert-Macmillan and Leitz (1986), Cobb et al (1988), Rosenbaum et al (1989), Bershon (1992), Heller, Keith, and Anderson (1992) and Davenport and Howe (1999) highlight the point that cooperative problem solving is a learning situation which is rich in social interaction necessary to improve the exchange of speech and the cognitive development. Also, many researchers have mentioned the effectiveness of cooperative learning in enhancing achievement and the suitability to use it as an instructional method in problem solving lessons to help bridge the gap between computational skills and problem solving (Artzt and Newman, 1990, 1997). However, all of these issues will be highlighted in detail in the next chapter.

Problem solving is considered the heart of mathematics and many researchers have suggested the positive impact of applying cooperative learning strategies on students' achievement. This study, therefore, concentrates on assessing the effectiveness of cooperative learning strategies in promoting problem solving skills in mathematics which is considered the high-level of thinking.

3.6 General Mathematical Teaching Methods and Strategies

Despite the importance for teachers to look at learning and teaching theories to help in determining classroom practice, some mathematics teachers and educationalists have been very keen to look at these theories, others are not aware of them and yet others are against them. (Orton, 1992). The theory of " teaching mathematics includes a number of components" which are stated by (Ernest, 1991, pp. 208-209) and they are:

> " 1. genuine discussion, both student-student and student-teacher, since learning is the social construction of meaning; 2. cooperative group work, project-work and problem solving, for confidence, engagement and mastery; 3. autonomous projects, exploration, problem posing and investigative work, for creativity, student self-

> direction and engagement through personal relevance; 4. learner questioning of course contents, pedagogy and the modes of assessment used, for critical thinking and 5. socially relevant materials, projects and topics, including race, gender and mathematics, for social engagement and empowerment."

If the previous components are studied carefully they can be linked to the teaching methods and techniques that may be used in teaching mathematics and using cooperative learning highlights most of these components if it is applied in a correct way.

Johnson and Johnson (1974, 1987) characterised the teaching approaches to three major instructional methods: the use of cooperative, competitive and individualistic instruction. Also, they pointed out the insistence for all teachers, as an essential instructional skill, to know " how and when to structure students' leaning goals cooperatively, competitively, or individualistically."

Several teaching methods have been used to be applied in schools of mathematics. These methods have were classified and witnessed in the late 1990s when there was a return to the favour of such "traditional" forms of schooling, against "progressive" educational systems, with their influence of progressivism in the mathematics classrooms (Boaler, 1997). Hubbard (1991) highlighted that most researchers tried to assess the progressive methods based on discovery-based learning involving group problem-solving.

In fact, many writers have discussed several ways of teaching, especially mathematics. For example, Hubbard (1991) presented 53 interesting ways to teach mathematics by designing courses, such as small groups, giving lectures, conducting tutorial classes, using exercises, problems and problem solving, developing study skills and, finally, assessing learning. Also, Walters and Castle (1967) identified some teaching methods, such as classroom teaching, which are the traditional methods of teaching, group methods, individual work projects and centres of interest.

In each class there are many teaching strategies which can be applied by the teacher during the implementation of the lesson in order to achieve the general and the specific aims of the lesson. Before these strategies are discussed a simple definition of the strategy in teaching will be given. Abu-Zena (1997, p.105) gave the following definition of the strategy:

> " the strategy is the way of work that is determined by a specific system during a period of time to achieve its goals, to solve its basic problems, and to apply its polices."

In order to determine the suitable strategies in teaching it is necessary first of all to determine the general teaching objectives and to plan for these strategies because they will be translated into tools and procedures in order to be used in the implementation. In general, Abu-Zena sees that the teaching strategies components are:

- the teaching objectives
- the teacher's moves
- the examples, exercises, problems and tools that are used to achieve the goals
- the learning atmosphere and the class organisation
- the students' response with all its different standards.

The teacher is the person responsible for determining the objectives and the aims of the lesson and to choose the procedures and the content that are suitable for these objectives. He/she must let the students interact with the subject, create the competitive and cognitive atmosphere, present useful examples and exciting exercises and problems upon the students and, finally, measure and evaluate the students' performance according to these objectives.

In the classroom the teacher makes several continuous and arranged moves. The following moves are some of the common ones that are used during mathematics lessons: exposition, illustration, demonstration, discussion, training, exploration and class management (Abu-Zena, 1997).

Students' response represents the learning process and it can be said that students do not learn anything unless they are able to do some mathematics. The students' response has been classified by Bloom into six standards: knowledge and recall, understanding and comprehension, application, analysis, synthesis and evaluation.

Teaching strategies can be classified as traditional teaching strategies, individualised instructional strategies and other strategies that are build according to the discovery learning principles. Each of these strategies has its own sequence of steps and moves that are described by Abu-Zena (1997).

The traditional strategies are the common ones that are usually used in teaching mathematics. They can be described in the following ways:

1. starting by giving information to the students, such as giving a rule or discussing an algorithm; usually this can be applied by the exposition, illustration and demonstration moves
2. mastering the skill, storing the information and recalling it; often this can be applied by the training moves with the students and by solving exercises and problems.

Because of the weakness of this strategy it does not encourage students in interaction, contribution, making different activities and self learning; even more, it does not enhance active learning. Other strategies have been applied that concentrate on self learning by using individualised instruction which depends on searching for specific materials and programmes related to students' ability and encourage self learning by being given guidance by the teacher. In such teaching strategies the learner does different activities without cooperating with teacher and peers. Hence, it does not encourage active learning and does not offer a chance for interaction and active contribution in the class between the learners themselves and the teacher. In the light of these disadvantages, a new direction has been applied that concentrates on learning by discovery. Cooperative learning is one of the famous methods used to apply these strategies and create the competitive and cognitive atmosphere in the classroom to enhance interaction, cooperation, excitement, pleasure, enjoyment, exploration and discovery. Actually, learning by discovery has taken a significant place in recent years, especially in mathematics. It can be considered a method of learning. Teaching by discovery may be guided or free and it can be applied by inductive or incidental ways (Love and Tahta, 1991).

Although there are several teaching methods and strategies, little variety exists in the teaching methods used in Jordan. In recent years, there has been an educational political desire (as was discussed in detail in chapter two) to develop the teaching and learning process in such a form to enhance the use of teaching strategies that are built according to the discovery learning principles which is the main role in the learning situation for students. This environment can be described as student-centred learning. However, traditional classes in Jordan still concentrate on using traditional strategies, that have been discussed previously, where the information is presented didactically by the teacher and where the teaching and learning situation can be described as teacher-centred.

The philosophy of the researcher in this present study is to explore the effectiveness of cooperative learning strategies on students' achievement and problem solving skills in mathematics as a progressive method of teaching compared with traditional teaching methods and strategies, on the basis that this instructional method may play a role in moving the teaching and learning situation from a teacher-centred approach to a more student-centred approach.

Since two of the factors that may influence the teaching and learning process are the teachers characteristics and the teaching skills, this study explores how teachers usually teach in their traditional classes and what teaching strategies are involved in their experimental classes to investigate how they may affect the learning process. This was conducted during classroom visits within the experiment and analysed and discussed within this study.

In the next section some details will be discussed about the traditional teaching to explain and to describe it as a routine method that is usually used in the teaching of mathematics.

3.7 Traditional Teaching Methods

The traditional methods of teaching have been used in mathematics classes for more than a hundred years. Walter and Castle (1967, p.153) defined the traditional method as one of the teaching methods that used to be applied and they stated

> " that is, class teaching. Here the teacher expounds the lesson to the class, using the black-board and chalk, asking questions of the class, perhaps requiring two or three children in turn to demonstrate

> on the board, and the writing up sum questions or examples to be worked by the class, or a summary to be learned."

In this traditional "chalk and talk" method the teacher explains the lesson on the black board at the front of the class for the first 15 to 20 minutes. Then they discuss the lesson by asking some questions to be worked by the students within the class. Most teachers question students whilst lecturing from the blackboard. Then students work through their textbooks in every lesson (Boaler, 1997). Most students sit in pairs in their class, but they work alone. When the teacher talks from the front of the class, the students sit in silence listening to their teacher, watching the board and writing what they are told. Hubbard (1991, p.11) described the traditional teaching method and stated that

> "lecturers in mathematics now face a situation in which their students may have been taught in schools in a fairly traditional way, working from established textbooks under tight control by a teacher."

Saye (2002) supported Hubbard when he described the traditional method in teaching mathematics and said:

> " Usually mathematics teachers lecture when they teach their classes. In a traditional classroom setting, the teacher will begin class by answering questions from homework, then she will teach the new lesson, and finally she will give a homework assignment that students may be able to begin working on in class if time permits."

Although applying traditional teaching methods in mathematics take place in most classes in schools, this method has many disadvantages. Saye (2002) commented that this method is often boring because the only role for the students is to watch, listen and copy what the teacher does and, in these circumstances, they begin to feel that mathematics is pointless and not related to them in real life. On the other hand, the disadvantages for this method also reach to the teacher himself/herself because, during the lesson, most students will have difficulties in listening, copying and, at the same time, understanding the lesson. So, both students and teacher are often frustrated and, when they begin working assigned problems at their desks, they raise their hands asking for help from the teacher while the teacher moves around the room trying the answer their questions. He/she will be exhausted from moving around the room, the lesson will finish and he/she will feel disappointment that he/she can not effectively meet the needs of his/her students (Saye, 2002).

Walters and Castle (1967) commented that, in these classes, teaching reaches only some of the children and, for others, it is a waste of time. This method may also create some bad behaviour, like selfishness, self liking, non cooperation, defenceless rioting, and may also build negative attitudes toward mathematics, school, teachers, and, perhaps, towards classmates, too.

The previously identified disadvantages may not be the only ones. This method of teaching may not play a role in students' progression and, perhaps, keeps the students at the same level they are without promoting their skills in doing mathematics. ACEPT Faculty Workshop (1997) reported that, in scientific research, using traditional teaching methods is unrelated to the creative reasoning and experimental design process. Moreover, it does not actively engage students or emphasise problems that are relevant to students' lives in traditional mathematics courses. For these reasons they suggested the use of collaborative groups and student-centred learning in such courses to enhance the learning process.

This study will investigate the previous points through an experimental research programme to compare cooperative learning with traditional methods on students' achievement and the methods' effectiveness in promoting problem solving skills in mathematics. Also, this present study will explore other advantages and disadvantages in applying such methods in the teaching of mathematics.

3.8 Conclusions for Research Construction

The contents of this chapter analysed the research construction on the base of the philosophy of mathematics education that consists of four co-ordinations, namely: the nature of teaching, the nature of learning, the educational aims and the philosophy of mathematics. The investigation of the literature indicated the following issues.

1. The nature and philosophy of mathematics does not only concern all kinds of mathematics knowledge that is done and has been done in the last four thousands years, but it is how to account for its nature and how it is that human beings are able to do mathematics. One of the basic aims of this present study is

to explore how to improve the quality of learning to promote students' ability to do mathematics.

2. Both the theory of teaching mathematics and the theory of learning mathematics highlight the need for effective teaching approaches that are necessary to create a learning environment that is rich, challenging and sufficient to build self confidence, positive attitudes and good feeling. Such teaching approaches allow students to investigate, explore, discover, play, discuss, and making activities and cooperative work, too. This study investigates the effects of the nature of teaching on the nature of learning by assessing the rationality to use the cooperative learning environment in the mathematics classroom and how it might contribute to the broader development of the students.
3. Mathematical problem solving skills are the basic elements in the mathematics construction that is considered in the high level of thinking and mastering such skills is one of the basic aims in mathematics education to help students reach the standard required to become problem solvers. This study assesses the effectiveness of cooperative learning strategies versus traditional ones in promoting problem solving skills and other achievement in mathematics.
4. There are several teaching strategies and techniques which can be applied within the mathematics classroom. These strategies can be classified into three major approaches:

- traditional teaching approaches that could be described as teacher-centred
- individualised instructional approaches (self learning)
- learning by discovery approaches that could be described as student-centred.

The researcher's philosophy in this present study is to assess the effectiveness of cooperative learning strategies that may play a role in moving the teaching and learning situation from a teacher-centred approach into a student-centred approach. Moreover, the study explores teachers' teaching skills in the two experimental groups and how it might affect the learning process.

Chapter Four

Cooperative Learning

Chapter Four
Cooperative Learning

4. Introduction

Cooperative learning is an instructional approach that has always been used in different stages and subjects all over the world. The concept of cooperative learning has its particular meaning where researchers and classroom teachers find that group work is more effective when it satisfies specific components. However, there are different cooperative learning methods; all of them share the idea that students work together to learn and be responsible for their team-mates' learning as well as their own.

Slavin (1987b) pointed out that cooperative learning research has been based on two basic theoretical perspectives: developmental and motivational. This growing interest is a result of the fact that cooperative learning promises enhanced achievement as well as increasing social skills and interaction among students. It was found that cooperative learning is effective in different cognitive and non-cognitive domains (Slavin, 1983b).

Cooperative learning evidently has a place in mathematics instruction (Behounek et al, 1988) and it was found that it has its positive outcomes in enhancing students' mathematical achievement.

This chapter includes several sections that give details of the history of cooperative learning, the real meaning of cooperative learning, cooperative learning methods and the components and outcomes of cooperative learning.

4.1 The History of Cooperative Learning

Using the idea of cooperation in classroom is not a new innovation. Teachers in different educational stages use teaching styles similar to cooperative learning, such as "group projects, laboratory partners, and research teams" (Totten et al, 1991).

Research and studies on cooperation date back to the 1920s. Nevertheless, particular applications did not begin until the 1970s. At that time, several types of cooperative learning strategies had been developed, tested and employed. At present, researchers all over the world are studying practical applications of cooperative learning principles (Slavin, 1990a). However, the last decades have shown a revival of interest in cooperative learning and it has become increasingly popular in many schools throughout the United States, Canada, Australia, New Zealand, parts of Europe and Africa, and elsewhere. (Totten et al, 1991).

During the late 1960s workers in this field used terms such as "small-group learning or small-group teaching". In the 1980s the term cooperative learning became more commonly used (Davidson, 1990a).

Cooperative learning takes place in many subjects and through different stages. Calvin D. Crabill was one of the teachers who tried to use cooperative learning in mathematics classrooms. In the summer of 1968 he was working alone in his high school classroom on a secondary mathematics curriculum. The temperature was very high. The class was crowded with more than 60 desks in his room. It seems that, in that position, with the frustration and the exhaustion he felt, a new idea emerged in his mind to encounter the problems he faced because of the size of the class, the hard efforts he made to keep the students' attention on mathematics and the difficulty with access to students' desks. Suddenly, he started moving desks and placing them touching each other in groups of four, two by two facing each other. He felt terrific and began teaching in groups of four. The method worked and he came to believe that groups presented a solution to the classroom dilemma that had arisen historically (Crabill, 1990).

Another early experiment with cooperative learning in mathematics was with Jan Terwel. Her first experience with cooperative learning in mathematics was in the early seventies when she attended a conference in a small Dutch village. The subject at the conference was "Innovation in Dutch Secondary Education". New suggestions were being sought for an alternative method that could be used in the new comprehensive schools that were being established. Prof. Freudenthal, a well known Dutch mathematician, suggested having small heterogeneous groups within the heterogeneous class supported by learning by discovery. When Terwel employed this method she commented

> " I felt very interested and attracted. Freudenthal's ideas seemed to overcome many difficulties of other differentiation models".
>
> (Terwel, 1990, p. 229).

There has been a considerable growth in interest in different forms of group work in education and training in the U K since the early 1960s (Reynolds, 1994). Before that time the traditional organisation was used in certain types of school at least. Later on, a new direction was followed when the British Education Index listed twenty-one sources for team teaching, four of them were American and most of them were brief (Freeman, 1969). Much research in that field has been undertaken; for example, the ORACLE (Observational Research and Classroom Learning Evaluation) project. Professor Galton began this research that was extended for five years (1975-1980). The objectives of the project were to study the classroom practice at the University of Leicester that had increasingly focused on the problems arising from the interaction of pupils and teachers in the cooperative work (Galton and Williamson, 1992). Topping (1992) mentioned that applying cooperative group work is unlikely to be implemented effectively in UK classrooms. To give a reason to that he commented:

> " Practice in the United Kingdom has tended to lack the clear structure characteristic of North America Work, and objectives, procedures and evaluation would benefit from sharper definition. The sub-species of peer tutoring has frequently shown attainment and attitude gains for both tutors and tutees."
>
> (Topping, 1992, p. 156)

These are some examples of the beginnings of cooperative learning in the mathematics classroom. Since " necessity is the mother of invention", this strategy of instruction was born to solve many problems in the mathematics classroom. This study assesses the effectiveness of applying a new teaching method in the Jordanian mathematics classroom to promote problem-solving skills and achievement in mathematics where no interest or concern had been observed in applying cooperative strategies in the upper primary stages in Jordan until the recent concern had been implemented for the first four primary stages (Lower Primary Stage) in some Jordanian schools.

What does cooperative learning mean? What are the methods of cooperative learning? How can cooperative learning be effective? What are cooperative learning outcomes? These questions will be answered in the following sections of this chapter.

4.2 What Does Cooperative Learning Mean?

Cooperative learning is an instructional method in which students work together in their heterogeneous small groups composed of 4-6 members to solve a problem, complete a task or reach a common goal. (Nattiv, Winitzky and Drickey, 1991; Abrami et al, 1995; and Artzt and Newman, 1997). Johnson and Johnson (1987) show that a group member's task is not only to master his own learning material or solve a certain problem but, also, to be sure that every other member of the group has completed his task, too.

Students in their groups should believe that they should succeed as a team. So, they should cooperate, interact, share material and help each others to accomplish their goal. On the other hand, they should understand that they have individual accountability to master the material individually. Therefore, they should ensure that all team members had mastered the material. Thus, students search to get benefits from all those with whom they are cooperatively linked.

Students within their group may have different roles or specific tasks to allow opportunities for all group members to participate. Groups usually compete with each other to get group recognition.

Hence, we could see cooperative learning as Totten et al (1991, p. 1) mentioned, as

> " It involves a face-to-face interaction by all students, heterogeneous teams, structured goal interdependence (including a group gaol and group recognition), individual accountability and emphasis on practising social skills."

Cooperative learning does not only mean putting students together in small groups and giving them a task. It also involves very careful thought and concern to different features and aspects of the group process. (Davidson, 1990a).

Working together in cooperative groups implies discussion that motivates the development of meta-cognitive strategies. (Hoek, Eeden, and Terwel, 1999). For that reason they see that, from the cognitive perspective, encouraging learning in cooperative groups can be achieved by improving strategy through instruction to use cognitive strategies, like problem solving strategies such as forming real and frequent use of representation, planning, monitoring, checking, revising and presenting a feedback.

Johnson and Johnson (1987) reported that, in cooperative learning group situations, students work on the subject assignments; they discuss the material with other students in their group, explain how to complete the assignment, listen to each other and try to understand the solutions, and provide academic help and assistance. Hence, the cooperation arises in different aspects during the group work to achieve the group goal.

It should be clearly understood that cooperative learning not only means those students working in groups, sharing materials and helping one another. Learning cooperatively also involves face-to-face interaction with students in their heterogeneous groups. Moreover, it includes structuring goal interdependence, including a group goal, group recognition, satisfying individual accountability and practicing some social skills. (Totten et al, 1991). In another way it can be said that group work which includes the following components: individual accountability, group goals, task specialisation and social skill development is called cooperative learning in groups or teams. Groups are usually composed of 4 to 6 members and are generally heterogeneous in students' achievement level, gender and ethnicity. Providing teachers with the real meaning of cooperative learning is one of the most important things that guarantee effective implementation. This study is concerned with such issues especially with the training programme as will be discussed in the next chapter.

4.3 Cooperative Learning Methods

In the early 1970s research on particular applications of cooperative learning in the classroom began. Slavin (1990a) commented that

> "At that time, four independent groups of researchers began to develop and research cooperative learning methods in classroom settings. At present, researchers all over the world are studying practical applications of cooperative learning principles, and many cooperative learning methods are available."
>
> (Slavin, 1990a, p. 2-3).

Totten et al (1991) mentioned that

> "Due to the efforts of such individuals as Elliot Aronson, David Devaries, David W. Johnson, Roger T. Johnson, Spencer Kagan, Nancy Madden, Shlomo Sharan, Robert Slavin, Noreen Webb and others, a multitude of new cooperative strategies has been developed, field tested, and researched."
>
> (Totten et al, 1991, p. 2)

There are more than 50 cooperative learning instructional strategies (Nattiv, Winitzky, and Drickey, 1991). Most of them are explained and discussed in detail in Slavin et al, 1985, Slavin, 1990a, Totten et al, 1991, Kagan, 1992, Sharan, 1994 and Abrami et al, 1995. The following strategies are those which have been used most frequently.

1. Student Team Learning

Although all coperative learning methods share the idea that students work together to learn and be responsible for their team-mates' learning as well as their own, student team learning methods include the use of group (team) goals and group (team) success where "student's tasks are not to do something as a team but to learn something as a team" (Slavin, 1990a). There are many different types of student team learning that have been developed by Robert Slavin and his colleagues at John Hopkins University (Abrami et al, 1995). All these methods include three major concepts: team rewards, individual accountability and equal opportunities for success, but in different ways (Slavin, 1990a). A brief overview of these types are now discussed.

a) Student Teams-Achievement Divisions (STAD)

In STAD, students are assigned to heterogeneous learning teams, in students' level of performance, gender and ethnicity, composed of four members. After the teacher presents a lesson the students begin to work within their teams to make sure that all team members have mastered the lesson. At the end, all students take individual quizzes on the material without helping each other. The scores of the students' quizzes are compared to their own past averages and points are awarded based on the degree to which students can meet or exceed their own previous performances. Then the sum of these points form the team scores and high performance teams may earn certificates or other rewards **(team reward)**. These activities usually take three to five class periods (Slavin, 1990a). There are five components of STAD: class presentations, teams, quizzes, individual improvement scores and team recognition (Kagan, 1985). STAD has been used in many subjects and has been used particularly in mathematics classrooms from grade two through college (Slavin, 1990b).

Slavin (1990a) pointed out that there are many advantages for this method; it motivates students to encourage and help one another to master materials and skills. Students help their team-mates to learn the material so that they can earn rewards; they encourage their team-mates to do their best. Students compare answers, discuss any contradictions, help each other, discuss approaches to solving problems, quiz each other on the content they are studying, teach and asses their difficulties to help each other succeed with the quizzes. Moreover, although students study together, they solve their quizzes individually, this **individual accountability** encourages students to help each other in a good way, where the team has no way to success unless all team members have mastered the material. Since team scores depend on students' improvement over their own previous scores, (**equal opportunities for success**), any student can be the "team star" in a specific week within the period of the study.

b) Teams-Games-Tournaments (TGT)

Teams-games-tournaments, developed by David Devries and Keith Edwards, was the first of the John Hopkins' cooperative learning methods (Slavin, 1990b). This method is very similar to STAD but, instead of using individual quizzes, it uses weekly academic game tournament competitions between students from different teams. In TGT all students participate to compete with members of other teams to contribute points to their team scores **(individual accountability)**. Each three students compete against others with similar past scores. Every week the students' "tournament table" changes and keeps the competition fair. The winner brings six points to his or her team; middle scores earn four points and low scores earn two points for their teams. Finally, teams that gain high performance earn certificates or other forms of team recognition or reward **(team reward)**. This method allows low achievers, as well as high achievers, to contribute points to their teams and compete with others at the same level **(equal opportunities for success)** (Slavin, 1990a).

This method gives all students a chance to participate with different levels of ability. It provides the element of excitement contributed by the use of games. Moreover, it encourages team members to help one another prepare for the games by studying work sheets and explaining problems to one another. The same materials used in STAD are also used in TGT but the difference is that the STAD quizzes are used as games in TGT. Some teachers use STAD, others prefer to use TGT because of its features that create the fun and activity and some teachers combine the two (Slavin, 1990b).

c) Team Assisted Individualisation (TAI)

Team assisted individualisation (TAI) is also known as team accelerated instruction (TAI) (Totten et al, 1991). This method shares with STAD and TGT methods the use of four member mixed-ability learning teams and rewards for high-performance teams **(team reward)** but, while STAD and TGT use a single way of instruction for the class, TAI combines cooperative learning with **individualised** instruction (Slavin, 1990b). This strategy is designed specifically to teach mathematics to elementary students (Webb, 1985; Slavin, 1985b; and Slavin and Karweit, 1985). All participants complete an individual unit of the material studied based upon their scores on a placement test **(equal opportunities for success)** (Slavin, 1990a). Assigned to heterogeneous groups, team members check each other's work and help each other with problems. Slavin (1985b; 1987a) described the principal features of TAI as teams, placement test and curriculum materials. Actually, TAI strategy is a combination of cooperative learning and individualised instruction in mathematics and was developed by Slavin who concludes that the strategy has positive effects upon academic achievement, self-esteem, attitude towards mathematics, race relations and acceptance of mainstreamed classmates (Toten et al, 1991).

d) Cooperative Integrated Reading and Composition (CIRC)

Positive effects produced by cooperative integrated reading and composition (CIRC) are designed to teach reading and writing skills in upper elementary schools (Totten et al, 1991). Teachers use basic readers and reading groups (Stevens, Slavin and Farnish, 1991). Students are assigned to teams composed of pairs and work in their pairs on a series of cognitively engaging activities, including reading, discussing, guessing, summarising and writing. Moreover, students practice spelling, decoding and vocabulary. **Team rewards** are certificates given to high performance teams (Slavin, 1990a). Students have **equal opportunities for success** because they work on materials appropriate to their reading levels. In addition, CIRC satisfies the **individual accountability** because their teams' scores are based on their individual quiz scores and their final individual written compositions (Slavin, 1990a).

2. Other Cooperative Learning Methods

- **Learning together:** this strategy was developed by David Johnson and Roger Johnson at the University of Minnesota (Slavin, 1990a). Students work in their heterogeneous groups on assignment sheets. All of the group members work on a single sheet and receive praise and rewards according to their group results (Slavin, 1985a). Johnson and Johnson (1987) showed that this teaching method emphasises four principal elements. The first one, **positive interdependence,** is where students work together in their groups to achieve their goal. The second element is **face-to-face interaction**, where students work together in small groups (two to four members). The third element, **individual accountability,** is where students must individually master the material. The last one, **social skills development,** is where students are encouraged to practice interpersonal and small-group skills. Leadership, decision- making and other communication skills have to be taught to enable students to discuss how well their groups are working to achieve their goals (Johnson and Johnson, 1994).

- **Group investigation:** group investigation was developed by Shlomo Sharan at the University of Tel-Aviv (Slavin, 1990a). All students participate in their groups to prepare a presentation for the whole class where each group member is responsible on a **special task** to represent the final assignment (Slavin, 1985a; Nattiv, Winitzky, and Drickey, 1991). Kagan (1985, p. 72-73) described that students' progress within the group investigation method is achieved through six stages:

> " Stage 1: Identifying the Topic and Organising the Pupils into Research Groups; Stage 2: Planing the Learning Task; Stage 3: Carrying Out the Investigations; Stage 4: Preparing the Final Report; Stage 5: Presenting the Final Report; Stage 6: Evaluation."

- **Jigsaw:** jigsaw was designed by Elliott Aronson and his colleagues (Slavin, 1990a). Each student in a group is assigned a different part of the material to master. Students who are assigned the same topic meet each other then return to their group to teach the others their topic, so all students are responsible for learning their parts, as well as the others (Nattiv, Winitzky, and Drickey, 1991).

- **Roundtable:** the teacher poses a question having multiple correct answers or gives each group a worksheet. Each student in turn writes one answer as paper and pen are passed from one team member to the next (Nattiv, Winitzky, and Drickey, 1991; and Kagan, 1992).

- **Pairs check:** students work in pairs within groups of four, playing one of two roles. Each pair takes turns; one solves a problem while the other teaches. They switch pairs and check with the other pair in the group (Nattiv, Winitzky, and Drickey, 1991; and Kagan, 1992).

These methods are the most famous and frequently used in cooperative learning. There are others, like group project methods, the structural approach, cooperative concept mapping and others, that are discussed in Abrami et al (1995).

Within this study, several forms of cooperative learning strategies are used in the experiment. The cooperative learning strategies conducted do not take a specific form of cooperative learning previously mentioned but they are a mixture of several strategies which mostly concentrate on applying the student teams-achievement divisions (STAD) method, group investigation and learning together and, sometimes, a form of teams-games-tournaments (TGT). Strategies conducted within the experiment are discussed in detail in the next chapter to show how to use cooperative learning strategies in the mathematics classroom. The researcher decided to use this developmental model because it can easily be implemented in Jordanian schools in accordance with the educational system where students' achievement is evaluated according to their individualised scores. On the other hand, using different strategies allows teachers to use the most suitable one according to the lesson aims, the feature of the material and the classroom setting where the curriculum is fixed by the Ministry of Education and teachers should cover the material within a specific time. Applying this model allows good and effective implementation and makes no contradiction between the research aims and the Jordanian educational system. The strategies used within the experiment will be discussed in detail in the next chapter. These strategies include the most of basic components of cooperative learning that make such a teaching method effective in the mathematics classroom. The next section addresses these components.

4.4 How Can Cooperative Learning be Effective?

Cooperative learning has always had an important place as a method of instruction and it is one of the most thoroughly researched of all instructional strategies. The effects of cooperative learning award structures on student achievement are one of the topics that have been studied and researched. Several research studies have concentrated, through their investigations, on how cooperative learning can be effective. There is a consensus among researchers on cooperative learning that, if significantly positive student achievement is to be gained through the use of cooperative learning, then it is sufficient that such strategies include certain components.

Cooperative learning does not just let students sit together in their groups to talk with each other as they do in individual assignments. It does not mean finishing the group assignment that is done by one of them while the others just sit and look for his/her solution and just put their names on the product, as well. Cooperative learning is more than collecting students to sit near others in their group, discussing material and helping each other. Of course, in addition to that, there are some components that must be included in cooperative learning in order to apply it in a correct way and to achieve its effects.

Researchers and classroom teachers found that group work was more effective when the following components were included: individual accountability, group goals, task specialisation, face-to-face interaction, interpersonal and small-group skills, social skills development, equal opportunities for success, team composition, adaptation to individual needs and positive interdependence (Webb, 1982a, 1982b, 1982c, 1989, 1991; Johnson and Johnson, 1987, 1989; Slavin, 1990a, 1991; Totten et al, 1991; Nattiv, Winitzky, and Drickey, 1991; Cohen, 1994; Abrami et al, 1995; and Peklaj, 1996). These factors are considered as basic principal characteristics in cooperative learning methods.

- **Individual Accountability**

Individual accountability means that the success of the group is dependent on every student learning the material taught. That means that every group member is responsible for learning the material and mastering it (Johnson and Johnson, 1987) and has to do his best to succeed and have his effort recognised (Peklaj, 1996). A basic aim in the learning situation is to enhance the achievement of each individual student. Determining the level of mastery of each student is necessary so that those students can provide appropriate sustainment and assistance to one another (Johnson and Johnson, 1987). Many researchers found that cooperative learning strategies are effective if they include this component (Slavin, 1983a, 1990a; Davidson, 1985; Johnson and Johnson, 1987; and Abrami et al, 1995). Slavin (1990a) pointed out that individual accountability can be achieved in two ways. One is to have group scores be the sum or average of individual quiz scores or other assessments. The other is to have task specialisation, by giving each student a unique responsibility for part of the group task. He documented that earlier studies noted that the learning together studies that used individual accountability seem to have been more successful than those that did not.

- **Group Goals**

Establishing group goals means that the team members are helping one another to be successful and that they are working together in order to get the rewards, grades, or other form of recognition (Totten et al, 1991). Cooperative learning is usually used to gain some form of group goals. These may be certificates or other recognition given to groups that achieve a high level of performance as a team. Actually, student team learning studies are most of the studies that use specific group goals and individual accountability.

- **Task Specialisation**

Task specialisation is a basic element of jigsaw, group investigation and other task specialisation methods where each member of the group has his/her own specific and special subtask of the assignment to be completed (Slavin, 1990a). Often, each team member has a different role. Typical roles are co-ordinator, recorder, spokesperson, and gate keeper. Roles are rotated (Nattiv, Winitzky, and Drickey, 1991). That means that students are given responsibility for one unique part of the group's overall learning tasks and, hence, as Slavin (1990a) mentioned, each student will be proud of his or her contribution to the group. There are many advantages of task specialisation. It solves the problem of individual accountability by having each student be uniquely accountable for his or her own contribution to the group. In addition, it helps to avoid jealousy between group members. On the other hand, task specialisation has the danger that students will learn only about the subtopic or subtask that they are responsible for. To solve this problem, most task specialisation methods include procedures that allow students to share information they have gathered with group members and with the whole class. They may have quizzes on all topics and the scores are averaged to form group scores. So, the success of the group depends on the group members not only to accomplish their subtasks but also to do a good job of sharing information with their group members (Slavin, 1990a).

- **Positive Interdependence**

Johnson and Johnson (1987) commented that positive interdependence is the first element of the four basic ones to let the group work be truly cooperative. It is an important variable that mediates the effectiveness of cooperation. The best combination, bringing the highest result in achievement, is goal and reward interdependence (Johnson and Johnson, 1992). Positive interdependence exists when group members believe that they are linked with other members of the group in such a way that they cannot gain their goal unless the other do so, too.

Goal and reward interdependence mean that group members can have a common goal or they can get a group reward. This means that interdependence can be achieved through distribution of resources, roles or task in the group. (Male, 1990; Peklaj, 1996).

- **Equal Opportunities for Success**

This is a unique feature of student team learning methods where scoring methods are used to ensure that students have equal opportunities to participate and contribute within their teams. Equal opportunities for success exists as improvement points in STAD, as competition with equals in TGT and as adaptation to individual performance abilities in TAI and CIRC. (Slavin, 1990a).

There are other components, such as **team competition,** as a means of motivating student to cooperate within teams (Cowie and Rudduck, 1991) to get a **group reward** (Fantuzzo, King and Heller, 1992). Moreover, **adaptation to individual needs**, which appears in TAI and CIRC, adapts instruction to a student's individual needs. Johnson and Johnson (1987) and Peklaj (1996) mentioned another key element, which is **social skills**. These skills are very different from skills used in individual learning situations. They have to be taught through different learning situations. Johnson and Johnson (1987) classify **face-to-face interaction** among students as a basic element which must be included in order for small-group learning to be truly cooperative.

4.5 Cooperative Learning Outcomes

In recent decades many researchers have found that cooperative learning can have a positive effect on learning achievement in different learning fields, such as cognitive, social and affective domains (Sharan 1980, Slavin, 1980, 1983b, 1990a, 1991; Kerry and Sands, 1982; Johnson and Johnson, 1989; Slavin et al, 1985; Reid, Forrestal and Cook, 1989; Good et al, 1989/1990; Peklaj, 1996; and Shanahan, Topping and Bamford, 1994). Davidson (1990a, p.1) demonstrated that

> "Systematic and frequent use of small group procedures has a profound positive impact upon the classroom climates; the classroom becomes a community of learners, actively working together in small groups to enhance each person's mathematical knowledge, proficiency, and enjoyment. Frequent use of small groups also has an enlivening and invigorating impact on the professional lives of mathematics teachers".

Equally significant is that true cooperative learning strategies focus on both the cognitive and affective concerns of education. Such strategies concentrate in their aims to increase the academic achievement as well as the cooperative or social skills and interaction of students. Slavin (1991, P. 71) demonstrates that

> " The use of cooperative learning strategies results in improvements both the achievement of students and in the quality of their interpersonal relationships."

Supporting the learning process for students it is necessary to offer them the opportunities to describe their own ideas, hear their thoughts through others' explanations, ask questions and receive answers and explore various approaches. Actually, learning together through cooperative learning groups gives students more opportunities to interact with concepts than do traditional expository classes. Students do not only have the chance to speak, but they will feel comfortable in trying out their thinking during problem solving situations in sitting in their small groups. So, " such classrooms maximise the active participation of each student and reduce the isolation of individuals" (Burns, 1990).

The primary purpose of schools may be concentrated on academic learning but they provide the setting for much more. When pupils enter the classroom they are confronted by many possible goals to achieve, activities to engage in and challenges to face in different fields (Townsend and Hicks, 1997). Terwel et al (1994) pointed out that the causes of positive effects of group work in accelerating the learning process related to the cognitive theories because of the following type of learning environment: the socio- cognitive conflicts that emerged during the students' group work with their different solutions and points of view. This will also cause willingness in pupils and encourage higher cognitive skills.

Positive effects of cooperative learning can also be expected on the basis of the motivation theory. Moreover, it has a positive effect on improving a number of indications of interpersonal relationships that may be reflected in social satisfaction. Evidence is documented of the effectiveness of cooperative learning strategies for a wide range of outcomes: enhanced academic achievement; improved inter group relations; acceptance of mainstreamed classmates and self-esteem; built positive attitudes toward schools, classmates and mathematics (Slavin et al, 1985).

Here is a detailed description of cooperative learning outcomes in the cognitive and non- cognitive domains.

4.5.1 Cooperative Learning Outcomes in the Cognitive Domain

> " The power of cooperative learning lies in its ability to promote what is known as deep learning."
>
> (Millis and Cottel, Jr, 1998, p. 37).

The most important outcome of cooperative learning and the one that has been most widely researched is enhanced achievement. Cooperative learning can significantly enhance the learning of all students. There is a strong theoretical basis that explains that cooperative learning will increase student achievement (Slavin, 1987b). Many studies have proved that this method increases the academic achievement for students in many subjects and for different stages (Slavin, 1983b, 1990a; Kagan, 1986; Johnson and Johnson, 1987; Davidson, 1990a, Felder and Brent, 1994; Stevens and Slavin, 1995; and others). For example, of the 26 studies by Johnson and Johnson that include achievement data, 21 showed that cooperative learning promotes higher achievement, 2 studies had mixed results and 3 found no differences between conditions (Johnson and Johnson, 1985).

Also, Slavin (1990a) in his book, '*Cooperative Learning: Theory, Research, and Practice*' pp.19-21 listed tables 2-1 to 2-7 to summarise the research outcomes on the achievement effects of cooperative learning. The tables list sixty-eight comparisons of cooperative learning and control methods. Over all, the effects of cooperative learning on achievement are positive: forty-nine of the sixty-eight comparisons were positive

(72 %); only eight (12 %) favoured control groups. Also, a look at tables 2-1 to 2-7 pp. 19-27 reveals that the different cooperative learning varies widely in achievement effects, but it must always be remembered that many researchers (Slavin, 1980, 1983a, 1990a, 1992; Davidson, 1985; Johnson and Johnson, 1987; Totten et al, 1991; and Peklaj, 1996) agree that cooperative learning can be an effective means of increasing student achievement only if they include group goals and individual accountability. Since, in cooperative learning situations, students' goal achievement are positively correlated, students believe that they can achieve their learning goals if, and only if, the other students in the learning group also achieve their goals. Thus, students search for outcomes that are useful to all those with whom they are cooperatively linked since individual goals are assigned each day and since students' efforts are evaluated as a group and rewards are given accordingly. In the end, these procedures will increase and accelerate the academic achievement for all students and provide them with equal opportunities for understanding and success.

Several researchers have demonstrated the need for the use of cooperative learning in the mathematics classroom (Davidson, 1990a; Johnson and Johnson, 1990; Terwel, 1990; Runesson, 1997; and Jones and Wakefield, 1998). Several research studies have found that cooperative learning has a positive impact on students' achievement in the mathematics classroom. Davidson (1990a) shows that cooperative learning addresses learning problems in mathematics in a number of different ways. It provides the social sustenance, gives the opportunities for success for students at all levels of ability, solves many other types of learning problems in life and allows students to deal with more exciting perspectives of mathematical learning. Moreover, small-group learning helps students to discuss different proposed solutions and challenge ideas that enrich the discussion through students' listening, talking, explaining and thinking with others and gives more opportunities than the individualised instruction to develop students' ability in exploration and creative thinking.

As neither an example nor as exclusive, the following quotations from different research studies illustrated such findings.

Jones and Wakefield (1998, p. 67) in their study, *'How Many All Together? Peer Support in Mathematics at Key Stages 1 and 2'*, demonstrated that

> " The quality of talk which produced in the above example was elicited through a focusing device (the mathematical think board) which is based upon the belief that mathematical understanding develops through the building up of cognitive connections between four types of experience: concrete material, symbols, language and pictures".

Peklaj (1996, p. 153), in her study that was employed to examine the effects of cooperative learning in mathematics on different ability students, found that:

> " Students under cooperative learning conditions achieved no significantly greater progress than did the control group. There was a trend with medium ability students to learn more under cooperative learning conditions than during traditional lecture treatment. The opposite trend was found with low ability students who learnt a certain kind of material (measures transformation) better after having received traditional lecture and individual learning treatment".

Several researchers draw attention to applying cooperative learning strategies in mathematics problem solving, where a positive impact is expected on students' mathematics problem solving skills (Lesh, 1981; Hill, 1982; Gilbert-Macmillan and Leitz, 1986; Cobb et al, 1988; Rosenhaum et al, 1989; Artzt and Newmann, 1990, 1997; Bershon, 1992; Heller, Keith and Anderson, 1992; Heller and Hollabaugh, 1992). Some research studies give specific attention to such kinds of mathematical process at the high level of thinking. Rosenbaum et al (1989, p. 11) encouraged the use of cooperative learning in the elementary stages and reported that:

> "Working together, provided that pupils have a clear view of the task at hand and potential strategies of attack, will help bridge the gap between computational skills and problem solving. However, perhaps more important than achievement gains is fostering the idea that working together to solve problems is good. This cooperative attitude has the potential of carry-over into other areas of our competitive world".

In a study (*Cooperative Small Groups: a Method for Teaching Problem Solving*) by Gilbert-Macmillan and Leitz in the elementary grade children (1986, p. 9) found that:

> "Organizing the class into three- and four-member groups that are trained to work cooperatively can provide an instructional setting effective for improving students' problem-solving skills."

Davenport and Howe (1999), in their study that is designed to investigate the effects of children solving addition and subtraction problems collaboratively in comparison with solving problems in the traditional classroom, demonstrated that:

> "The results themselves revealed variations in the way that children of different ability levels and gender can benefit from collaborative group work and thus have some interesting implications for the organization of collaborative groups in the classroom".

Research used by Johnson (1985) to study the effects of groups of four cooperative learning models on students problem solving achievement in mathematics for fourth and fifth grade students concluded that students in the experimental group demonstrated statistically significantly higher problem-solving achievement than the individual students who had not experienced the model.

4.5.2 Cooperative Learning Outcomes in the Non-Cognitive Domain

Within cooperative group work. all students work equally together to achieve their common goal. Cooperative learning also creates pleasure and a fun atmosphere. It encourages students to practice different kinds of social skills. Moreover, the affiliation between students may build inter-group relations during the group-work and, hence, it is logical to expect that cooperative learning would have positive effects on social, motivational and attitudinal outcomes as well as on the cognitive domain to build positive outcomes in the affective, motivational and social domain, as well as in achievement.

Commenting on key research findings, Joyce, Showrs, and Rolheiser-Bennet (1987, P.17) reported that:

> "Research on cooperative learning is over-whelmingly positive and the cooperative approaches are appropriate for all curriculum areas. The more complex the outcomes (higher, order and attitudes), the greater are the effects. The cooperative environments engendered by these models have substantial effects on cooperative behaviour

> of students, increasing feelings of empathy for others, reducing inter-group tensions and aggressive and antisocial behaviour, improving moral judgment, and building positive feelings toward others, including those of other ethnic groups.... We would not expect that the implementation of cooperative learning strategies on a wide treatment reported in research literature, but solid effects should occur in schools where adequate and well-designed staff development is provided."

Kagan (1985, p. 67) mentioned that cooperative learning

> "usually (1) enhances student achievement, especially the achievement of minority and low- achieving students; (2) improves cross-ethnic relations; (3) aids in the successful mainstreaming of handicapped students; (4) facilitates the maintenance of minority cultural values; (5) promotes positive social relations and prosocial development; and (6) increases the liking among students for class, school, learning, and self."

Cooperative learning has been shown, in a wide variety of studies, to have a positive impact on important non-cognitive variables, such as students' attitudes toward mathematics, students' self-esteem, peer academic support, internal locus of control, time on-task, liking of school, class and of classmates, cooperativeness and acceptance of others. A detailed discussion of the most extensive outcomes of cooperative learning in the non-cognitive domain are now presented.

1. Building Positive Attitudes towards Mathematics

Several research studies have found that the positive effect of cooperative learning on the affective domain is where students' attitudes toward mathematics is one of the most basic outcomes in that domain. Yusof and Tall (1999, p. 67), in their research that was looking for the effects on students' attitudes of a course encouraging cooperative problem-solving in university mathematics and reflection on the thinking activities involved, found that:

> " During the problem-solving course the changes were almost all in the desired direction. During the following six months of standard mathematics lecturing, almost all changes were in the opposite direction".

Drzewiecki and Westberg (1997, Internet Reference), in their study to assess gender differences in high school students' attitudes toward mathematics in traditional versus cooperative groups, found that cooperative learning has significant effect on male students' attitudes, but, on the open-ended items on the survey, they commented that:

> " Students enrolled in the classes using cooperative grouping procedures indicated that, in general, they enjoyed working in cooperative groups because they were able to provide help and receive help from their peers, share ideas on solving mathematical problems, check answers with other students and, ultimately, understand the material more easily".

2. Building Positive Inter-group Relations

Human beings have strong needs for contact and communication with others. Many pupils like attending their schools in order to be with their friends. So, schools have the task of promoting students' interpersonal skills as well as students' achievement (Schmuck, 1985). Davidson (1990a) mentioned that schools' discipline preventing students from talking to one another in class, but, conversely, by encouraging students to interact with others in the learning situation, will allow the teacher to meet an essential human need in order to facilitate and use the peer group as a constructive force to enhance academic learning. Hence, cooperative learning makes use of basic features of human nature. Webb (1985) mentioned that one feature of the cooperate learning method that makes it more distinguished than others is that this method gives a chance for interaction between students. The importance of developmental peer affiliation is clear since children and adolescents have feelings of friendship and of social importance that early adolescents attach to competence in different schools activities (Townsend and Hicks, 1997). Good et al (1989/ 1990, p. 56) reported that:

> "The potential benefits of work-groups - enhanced motivation and enthusiasm, positive peer interaction, and advanced mathematical thinking- warrant further trails of the format in classrooms, as well as the development of more appropriate materials".

Johnson and Johnson (1985, p. 112) commented that

> " Of the 37 studies that we have done that include interpersonal attraction data, in 35 studies cooperative learning promoted greater interpersonal attraction, in 2 the results were mixed."

Actually, the cooperation between students is supported through the group reward and the group goal and even by the teacher, who always tries to communicate an "all for one, one for all attitude" (Slavin, 1990a). Hertz- Lazarowitz and Miller (1992) in their book *'Interaction in Cooperative Groups'* concentrated on the value of cooperative learning in the interaction between students through many studies and research specialised in that field.

3. Acceptance of Academically Handicapped Students

Studies on cooperative learning that search for the effect of the cooperaive learning strategies on the acceptance of academically handicapped students found that cooperative learning is successful in the acceptance of academically handicapped students (Kagan, 1985). Moreover, Slavin (1990a) pointed out that this improvement can be gained while achievement is being increased for all students in the class. Conversely, structuring traditional classrooms contributes to the expression of a negative effect towards low achieving students. In the traditional classrooms most students usually compete with one another for acceptable grades and other rewards (Johnson and Johnson, 1974). Low achieving students, because of their weakness, would not be able to get the reward that students are competing to gain in the competitive traditional classes (Slavin, 1990a; Stevens and Slavin, 1995). Hence, a negative effect towards low achieving students could found. Slavin (1990a) pointed out that classes which create a cooperative atmosphere rather than a competitive one are seen to increase the acceptance of academically handicapped students who will have the opportunity to contribute to the success. Johnson and Johnson (1985, p. 118) commented that several research studies found that

> " Cooperative learning experiences, compared with competitive and individualistic ones, have been found to result in stronger beliefs that one is personally liked, supported, and accepted by other students, that other students care about how much one learns, and that other students want to help one learn."

4. Positive Effects on Students' Self-esteem

The effect of cooperative learning on students' self-esteem is one of the most important outcomes of cooperative learning because it is expected that students will feel that they are well liked by others, they are doing academically well, they are valuable and they have self confidence to take their decisions (Slavin, 1985a; Slavin, 1990a). Several research studies found that cooperative learning has positive effects on students' self-esteem (Kagan, 1985; Slavin, 1990a).

5. Creating Peer Academic Support

Cooperative learning encourages students to help each other to do academic work and enhances students' feeling that their classmates want them to do their best. So, this form of peer support enhances students' achievement (Slavin, 1990a). Jones and Wakefield (1998) found that one of the advantages of cooperative learning is creating peer support that develops an enjoyment and understanding of mathematics.

6. Positive Effect in Internal Locus of Control

Cooperative learning makes students feel that they have a chance to succeed, that their efforts will lead them to succeed and that success is a valued goal. Cooperative learning tends to give students more control over their own learning and they begin to feel that their success is dependent on their efforts and their personal behaviour but not on luck or chance (Slavin, 1990a; Jones and Wakefield, 1998). So, cooperative learning has a positive effect on the internal locus of control. Many studies have found that internal locus of control is positively influenced by cooperative learning (Slavin, 1990a; and Jones and Wakefield, 1998).

7. Increasing Time on Task

Slavin (1990a) mentioned that most research and studies that measure time-on-task have found that, in cooperative learning classes, the proportion of students' class time spent on-task is higher than that for control students (those how do not use coperative learning). He commented that this is because of the social feature of the task in cooperative learning strategies that increases time-on-task by engaging students' concern and by encouraging them to master the academic materials. Johnson and Johnson (1985, p. 116), when they observed the amount of on-task time in three cooperative, competitive and individualistic types of learning situations, concluded that

> " Cooperative learning situations may promote more on-task behaviour than the other two goal structures, but probably, there is little difference in observed actual on-task behaviour among the three goal structures".

8. Positive Effects in Liking School, Class and Classmates

Cooperative learning methods have a positive effect on liking class, liking school, liking subject matter being taught by cooperative learning methods and the relationship between the classmates (Kagan (1985), Johnson and Johnson (1985) and Slavin (1990a)). Many studies and researchers have found a positive impact due to applying the cooperative learning to enhance such outcomes.

All advantages mentioned previously are the most important non-cognitive outcomes in cooperative learning methods. These outcomes have domains such as, social outcomes, motivational outcomes and affective outcomes. This present study will assess the effectiveness of applying cooperative learning strategies to enhance such outcomes that may give other indications to the rationality for using cooperative learning in the mathematics classroom where these outcomes may play an indirect role to enhance the learning process.

4.6 Conclusions for Research Construction

This chapter has reviewed basic headings in cooperative learning, namely: cooperative learning in history; the meaning of cooperative learning; cooperative learning methods; how cooperative learning can be effective; cooperative learning outcomes. Analysing the contents of these subjects was necessary to establish the theoretical framework for this present study in order to fill the gaps in the available literature in different fields.

1. Although cooperative learning has been applied in different countries and researched extensively, no interest had been observed in applying the strategy in Jordan in the upper primary stage. This study assesses the rationale for using cooperative learning in the upper primary stage in Jordanian mathematics classrooms.

2. Although there are different cooperative learning methods, each one has its specific design and procedures in implementation and, hence, each one of them satisfies specific needs. In order to improve the quality of implementation of cooperative learning, this present study has developed the model facilitating:

- implementation in Jordanian schools according to the educational system where students' achievement evaluation is based according to the individual scores
- flexibility that allows teachers to use suitable strategies according to the lesson aims, the feature of the material and the classroom setting. However, the model of implementation is a mixture of several strategies mostly concentrated on STAD, learning together, group investigation and, sometimes, a form of TGT.

3. Although each cooperative learning method satisfies specific components of the cooperative learning the model of the implementation had been developed in order to satisfy most of these components.

4. Although several research studies found cooperative learning positively affects students' outcomes in the cognitive domain, most of these studies concentrate on assessing its effectiveness on students' general achievement. This present study concentrates on assessing the effectiveness to promote problem solving skills that are considered at the high-level of thinking.

5. Although several research studies draw attention to the use of cooperative learning in the mathematics problem solving, a lack in applying empirical research studies in that field has been observed in mathematics at upper primary stage where most research concentrates on applying in the early elementary stages. This was an impetus to conduct this research study.

6. Several research studies have found that cooperative learning has positive outcomes in the non-cognitive domain. In order to examine the rationality for using cooperative learning in the mathematics classroom and how it might contribute to the broader development of the students, this present study explores such outcomes.

The next chapter will discuss in detail how to use cooperative learning strategies in the mathematics classroom. It will highlight how cooperative learning strategies will be applied within the experiment according to the literature review and the researcher's development. The development for the implementation is done by the researcher in order to satisfy the basic components of the cooperative learning within the implementation for effective one that is suitable to be implemented in the Jordanian schools. It will concentrate on presenting the teachers' role and the teachers' decisions in the implementation. It will discuss when and why to use such a teaching method in the mathematics classroom, how to start the implementation, how to teach cooperative problem solving lessons and how to adapt a mathematics lesson to use cooperative learning.

Chapter Five

The Use of Cooperative Learning in the Mathematics Classroom

Chapter Five

The Use of Cooperative Learning in the Mathematics Classroom

5. Introduction

Using cooperative learning strategies in the mathematics classroom requires a different approach to planning and teaching than other traditional methods of instruction (Robertson, Graves, and Tuck, 1990). Tiberius (1999), in his book *'Small Group Teaching: A Trouble-Shooting Guide'*, addresses several problems that may arise within the group-work that are related to group goals, group interaction and group motivation and emotion. However, in order to implement this method it is very important first of all to provide the teacher with the best framework to help her/him for effective implementation and to avoid, as far as possible, any problems that may arise.

The teacher is the person who is responsible for organising the classroom, providing the information, explaining the concepts and skills, giving examples, evaluating the students and providing feedback to support the learning situation (Burns, 1990). So, cooperative learning needs to be well organised by the teacher. Terwel (1990, P. 245) stated that

> " Without coordination, systematic instruction, and management from the teacher, cooperative learning may turn out to be neither cooperative nor learning. "

To incorporate cooperative learning strategies successfully in classes, teachers should understand the real meaning of cooperative learning; they should believe in its value and the rationality for using it, and they should be given guidance regarding its application.

The contents of this chapter are discussed within the teachers' training programme (see appendix seven) and they are used as a base to prepare the Arabic syllabus for training them in how to use cooperative learning strategies in the mathematics classroom. This syllabus had been used during the training of the teachers as a key for them to explain the rationality for using cooperative learning, to support them with the basic framework and to answer the following questions.

1. What does cooperative learning mean?
2. Why use cooperative learning in the mathematics classroom?
3. What are the principal components of cooperative learning?
4. When should cooperative learning be used in the mathematics classroom?
5. What are the teacher's roles?
6. What are the teacher's decisions?
7. How should the implementation of cooperative learning be started?
8. How should cooperative learning problem-solving lessons be taught?
9. How should mathematics lessons be adapted for using cooperative learning groups?

5.1 Providing Teachers with a Good Definition of Cooperative Learning

It is important to provide teachers with a good definition of cooperative learning as an instructional approach in which students work together in their heterogeneous small groups composed of four to six members to solve a problem, complete a task or achieve a common goal. It is worthwhile informing teachers that this strategy of instruction used to be known as small-group learning or small-group teaching but, nowadays, the term cooperative learning has become more wide spread. However, teachers must believe that it involves more than just collecting students together in small groups and giving them a task. They should be aware that it also involves very careful thought to different aspects and features of the group process.

To encourage teachers in the use of the cooperative learning, it is useful to inform them that cooperative learning takes place in many countries for various subjects through stages and it takes place especially in the mathematics classroom. It must be explained to them that small-group cooperative learning can provide an alternative to both traditional whole-class expository instruction and individual instruction systems and that many researchers all over the world (as mentioned previously in chapter four) found that cooperative learning has positive effects upon academic achievement. However, in such research, it is necessary to inform teachers that the main aims of this present study are to examine empirically the rationality for using cooperative learning in mathematics, assess its effectiveness on promoting problem-solving skills and how it might contribute to the broader development of Jordanian students in the upper primary stage.

One important point that must be explained and discussed for teachers who are trained to use cooperative learning strategies is that researchers and class room teachers found that group work is more effective and satisfies its objectives in instruction if, and only if, it includes the principal components. The following section highlights this issue.

5.2 What are the Principal Components of Cooperative Learning?

In cooperative learning students work together as a team to solve a problem, complete a task or accomplish a common goal. However, although there are several types of cooperative learning strategies, teachers should be aware that all of them have certain elements in common to ensure that students are working cooperatively. These are common elements in all cooperative learning strategies (Artzt and Newman, 1997).

1. All team members must perceive that they are part of a team and they all have a common goal.
2. All team members must keep in their mind that the problem they are to solve is a group problem and the success or failure of the group will be shared by all of the members of the group.
3. All team members must talk with one another to engage in discussion of all problems to accomplish the group's goal.
4. All team members must perceive that each member's individual work has a direct effect on the group's success.

Actually, researchers and classroom teachers found that group work was more effective and satisfied its objectives in instruction if it includes the following components (as they were discussed in detail in the previous chapter): individual accountability, group goals, task specialisation, social skill development, equal opportunities for success, team competition, adaptation to individual needs and positive interdependence and, in order to satisfy most of these components, teachers must be responsible for the implementation of effective cooperative learning.

Within the contents of this chapter, the researcher highlights how to achieve these components during implementation. All teachers' moves will be discussed in detail after the following two sections.

5.3 Why Use Cooperative Learning in the Mathematics Classroom?

There is a wide range of theoretical models to explain the superiority and rationality of cooperative learning. The theories concentrate on two major categories: motivational theories and cognitive theories (Slavin, 1987b, 1990a; Terwel et al, 1994; Abrami et al, 1995; Millis and Cottel, Jr, 1998). Also, Reynolds (1994) summarised the reasons for using groups as motivational, educational, or ideological.

Motivational theories focus on the reward or goal instruction under which students operate to achieve their goals. Cooperative learning has positive effects based on motivation theory. It intensifies the learning process. Students are strongly oriented towards their peer group and very interested in interaction with their peers, working together, helping others and encouraging each others to do their best to achieve success as a team (Slavin, 1987b).

From the cognitive perspective, different cognitive theories, which fall into two major categories, development theories and cognitive elaboration theories, explain the rationality for using cooperative learning where these theories emphasise the effect of working together in itself (Slavin, 1990a). Cooperative small groups offer group members the opportunity to profit from the knowledge available in the group as a whole. This may take the form of knowledge, skills and experiences which not every member of the group possesses. In these circumstances pupils use each other as a resource. Group work also means that pupils are forced to speak their thoughts to facilitate understanding through cognitive reorganisation. They offer and receive explanations which enhance the learning process for effective problem-solving strategies by participating in the collective solution procedure. Also, Webb (1992) and Slavin (1992) gave a theoretical rationale for using small groups for when different kinds of help given and received are likely to be effective for learning.

As Davidson (1990a) described, the learning of mathematics is often viewed as an isolated, individualistic matter. One sits alone with paper and pencil and tries to understand the material or solve the assigned problems. Since mathematics is considered one of the most difficult subjects and many students are afraid of it, cooperative learning takes place especially in the mathematics classroom. Davidson (1990a) pointed out that cooperative learning addresses many problems in mathematical instruction in different ways. It provides a " social support mechanism" for the learning of mathematics and offers opportunities of success for all students in mathematics. Moreover, mathematical problems can be solved in different ways and, hence, in cooperative learning students can persuade one another by the logic of their arguments and can discuss different proposed solutions and learn several strategies for solving the same problem. Students in groups can help one another master basic facts and necessary computational procedures. They can deal with exciting aspects of mathematics learning. In this way, students can talk about the problem under consideration, discuss solution strategies and relate the problem to others that have been solved before, resolve difficulties and think about the entire problem-solving process.

5.4 When should Cooperative Learning be used in the Mathematical Classroom?

There are many opportunities for using cooperative learning strategies in the mathematical classroom (Artzt, and Newman, 1990,1997). Most activities can be enhanced by using cooperative learning strategies.

1. Problem Solving

It is very useful to use group work learning in problem solving lessons because, in these strategies, the group members engage in brainstorming (Gilbert-Macmillan and Leitz, 1986; Millis and Cottell,Jr, 1998). It is an activity that enables all members of the group to contribute to solving problems by using new ideas. The students who have a weak ability to solve such problems will be helped by other students in their team who are more able. All of the students will participate, not only to solve the problems but, also, they will share in the excitement the group experiences when the problem has been solved (Artzt, and Newman, 1990, 1997).

There are many ways to organise the work in problem solving (see appendix eight). The teacher may introduce one to two lessons for solving problems. After that, she/he may form a problem solving question sheet and ask each group to solve them during a week or she/he may post the problem solving activities on the bulletin board, to be solved by the team members after a certain period of time.

2. Developmental Lessons

It is very interesting to use group work learning in developmental lessons, which are designed for guided discovery leading to generalise a mathematical rule or statement (Millis and Cottell,Jr, 1998). To ask the team to achieve their task, the teacher may assign a subtask to each member of the team and, after each of them has completed his subtask, all of the members will contribute and participate to generalise and discover the general mathematical statement.

Once the statement has been written on the overhead projector or written on the chalkboard, the statements are compared and discussed by the class. The teacher will guide the students until all of them agree on the statement of generalisation. The students will enjoy their working and it will be difficult to forget something which they have discovered by themselves.

3. Enrichment Activities

Enrichment activities are considered important roles in mathematics education because they offer to students of all ages and ability the chance "to work in mathematics and to appreciate mathematics as a living, useful and interesting subject" (Artzt and Newman, 1990). The best way to interest students in a new topic is to use cooperative learning strategies. The students in each group will divide the work such that one of them looks up the dateline in the development of the topic, another finds out biographies of the mathematicians who were instrumental in the development of the topic, another looks for a story and events related to the topic. Finally, the group members will investigate how knowledge of this topic has affected the world as it is today (Artzt, and Newman, 1990, 1997).

4. Homework Review

Group work is an enjoyable and effective method that can be used to enhance the homework review. The group members will check the homework assignment, discuss their difficulties and come to an agreement on the best solutions. Ma (1996) found that middle and low achieving students all benefited from cooperative homework, whereas, high achievers did not, although they stayed in their top position in mathematics achievement.

5. Test Review

The teacher may give the students a sample test and ask them to work on it individually. Each student comes to the group to discuss with an accurate picture of his or her understanding. All students will participate in the review in order to prepare themselves for the forthcoming test. The teacher allows time for the whole class to discuss the problems which need more clarification (Artzt, and Newman, 1990).

5.5 What are the Teacher's Roles?

The teacher is an important figure; she or he plays a vital role in the implementation of effective cooperative learning. The teacher organises activities for the whole class and provides guidance for them, so she/he is responsible for the formation of groups and for the ways that incentives and rewards are used. There are basic roles for the teacher to follow for the implementation of effective cooperative learning. Kaye and Rogers (1968), Slavin (1977, 1978,1987c, 1983a), Johnson and Johnson (1989, 1990), Noddings (1989), Weissglass (1990), Terwel (1990), Davidson (1990b) and Artzt and Newman (1997) discussed most of these roles.

1. Explaining the assignment, the objectives of the lesson, the positive goal interdependence, the learning task, the expectations for the group, the expected collaborative behaviour, the procedures to follow and the definition of group success **(group goal).**
2. Structuring the materials and the instructions for the use of students such that each member of the group can contribute to the group's work.

3. Making sure that all students contribute to solving the problems, interact and cooperate with each other, share ideas and materials, support and encourage each other's academic achievement **(positive interdependence).**
4. Ensuring that students understand that they are individually accountable for completing the assignment and discovering methods to hold each student accountable for leaning the materials. This can be done by giving quizzes for all the students to solve separately without helping each other or by selecting a group member to explain the group's solution and randomly picking papers to grade **(individual accountability).**
5. Assigning students to groups that are heterogeneous in ability, gender and ethnicity. Actually, the researcher believes that it is also important to assign them in heterogeneous groups according to their communication skills, social class, personality and social behaviour.
6. Organising the classroom physically in such a way that the team-mates are close enough to one another to work together freely, comfortably and quietly.
7. Monitoring students' effectiveness in completing the assignment, moving quietly from group to group, observing the strategies, encouraging them always to work together and to help each other, helping the group members with the cooperative skill if they need help and if all team's members have difficulties in solving the problem.
8. Evaluating students' achievement to ensure that all of them have mastered the material.
9. Providing feedback after evaluation so that students know how well they are doing.
10. Asking the group members to monitor their performance, behaviour and functioning by asking questions such as: Does each student participate and contribute during your work? Are all students helping one another? Are all students mastering the material? Can you help me please? **(social skills development).**
11. Motivating the students to work and learn together in their groups and making cooperative learning attractive to students by providing incentives and rewards to the members of the best team. The rewards need not be expensive or elaborate **(group reward).**

12. Developing social skills, such as leadership, decision-making and other communication skills, should be encouraged. Also, encouraging students to give and receive help by asking questions, such as: Is there any body needing help? Would you mind helping me please? Can you explain this point again please? Can I ask you to help me in...? **(social skills development).**

5.6 What are the Teacher's Decisions?

Some decisions have to be made by the teacher in implementing cooperative group learning. The following decisions are the most important ones in applying cooperative learning correctly (Johnson and Johnson, 1990).

1. Deciding the size of learning groups

It is very important to decide the size of the learning group. Teachers' experience and researchers' outcomes found that it is better to keep the groups small, especially if the student's experience in cooperative learning is limited and if the period of the class is short (Artzt, and Newman, 1990). Each group should have four members, if possible, but, if the class contains a large number of students, or the area of the class is not wide enough, they may form groups of five or six students. Teachers in the mathematics classroom may form groups of two to six students. It is the teacher's decision to choose the size of the group especially if it depends on the size of the area of the class and the number of the students in the class.

2. Assigning students to groups

It is better for students to be assigned to groups by the teacher rather than by choosing their groups by themselves. After the teacher has decided the size of the learning groups, she/ he should know the number of the groups she/ he will have in her/ his class. She/he must distribute the students based on their academic preparation and ability, their gender, their ethnic background and any other characteristics that may prove useful (Millis and Cottell,Jr, 1998). Since schools in Jordan are separated according to sex and most students are from the same ethnic background, the teacher will distribute students relating to their academic preparation and abilities. He/she may follow the procedure that Slavin described in Student Teams-Achievement Divisions (STAD) (Slavin, 1990a). On a sheet of paper, the teacher arranges the students in her/his class from highest to lowest based on past performance using whatever information she/he has got. For example, the teacher may arrange them according to their last semester exam score but she/he must try to do the best she/he can. Then, the teacher uses her/his list of students arranged by performance to assign group letters to each student. For example, in a fifth-group class the teacher would use letters A through E, starting at the top of her/his list with the letter A and continuing lettering towards the middle. When she/he gets to the last letter, lettering will continue in the opposite order, as shown in figure (5.1). If there are students not assigned, they will be added to groups as extra students in different groups (see fig. (5.1)).

Figure (5.1): Assigning Students to Groups

Student's Performance	Rank Order	Group Name
High-Performing Students	1	A
	2	B
	3	C
	4	D
	5	E
Average-Performing Students	6	E
	7	D
	8	C
	9	B
	10	A
	11	.... B
	12	..... D
	13	A
	14	B
	15	C
	16	D
	17	E
Low-Performing Students	18	E
	19	D
	20	C
	21	B
	22	A

After the teacher has finished assigning students to groups, she/he will need to make one blank copy of a group weekly report (see fig.(5.2)) for every group members in her/ his class and fill in the names of the students or each Group Weekly Report.

During the implementation she/he must not change the group assignment, except under extreme circumstances, in order to keep the students working in their groups and develop a relationship between them as a whole group. Courcier and Stephens (1993), in their study to compare the effects of constant cooperative grouping versus variable ones on mathematics achievement among seventh grade students, found that there was no significant group effect. However, in this research the researcher will keep the group constant in order to assess the students' progress within the experiment in their groups and to encourage cooperative work and competition within the groups of each class.

Figure (5. 2): Group Weekly Report

Group Name ....

Group Members	Weeks / Quizzes								
	1	2	3	4	5	6	7	8	... ...
1. 2. 3. 4. 5.									
Total Group Score ÷ Number of members									
Average Group Score									
Group Recognition									
Group Leader									

After the teacher has finished this step, and if she/ he is not satisfied that the groups are heterogeneous in students' communication skills, social behaviour or any thing might be important of the view of teacher, it is her/ his decision to make some changes between students and before starting the implementation, but she/ he must ensure that they are from nearly the same level in order to keep groups heterogeneous in students' performance.

3. Arranging the classroom

After the teacher has finished assigning groups members, she/he must take care to organise the classroom for implementation (Terwel, 1990; Abrami et al, 1995). Within the class there are heterogeneous small groups of four to six students. To form these small groups, it is very important to take care that the members of the group are sitting close enough together so that they can easily interact with each other, share materials, talk to each other quietly, discuss, explain and solve their problems. Circles are the best, but the teacher may also arrange the students' desks opposite each other so that face-to-face interaction takes place in the group learning. Really, it depends on the resources which are available in the classroom.

It is a very important point that the teacher can integrate within groups easily and freely; even more, that students can move freely in the class. So, the groups must be separated enough in such a way that they do not interface with one another and the teacher must have clear access to every group.

4. Deciding how to distribute the instructional materials among groups

The teacher must decide how instructional materials will be distributed among group members so that all students have equal chances to participate and achieve (Johnson and Johnson, 1990). Materials can be arranged like a puzzle such that each student has a part of the material needed to complete the task, or, it may be a work sheet that must be prepared for each group to facilitate the group work. All the members of the group focus on the same problem and can check agreement before writing the answer. In order to record the answer to the problems, or apply the assignment, one copy of the group record sheet or answer sheet must be given to each group to ensure that the students will have to work together. They may be asked to use different colours to ensure that all of them participate in completing the task. It is very important, also, to provide individual record sheets or writing books for each student to record solutions or practice a skill to reinforce learning.

The teacher must always ensure that the materials support the academic and cooperative goals of the lesson. Moreover, it is very important to prepare other materials, such as construction papers, scissors, geometric instruments, colours, shapes, solid figures, over head projector (OHP) and other materials which may be used during the implementation of the lesson (Robertson, Graves, and Tuck, 1990). In general, cooperative group work reduces the quantity of learning materials needed but, in cooperative learning, preparation time may be greater than when planning other types of lessons.

5. Planning whether or not to assign students specific role responsibilities (task specialisation)

The teacher may assign students specific roles and then rotate the roles daily so that all the students play the different roles during a period of days (Millis and Cottell,Jr, 1998). The roles may be classified in the following way (Johnson and Johnson, 1990).

a. The Reader: who reads the problem to be solved to all members of the group.
b. The Explainer: who explains the task and the problem to be solved.
c. The Checker: who ensures that all group members can explain how to arrive at an answer or conclusion.
d. The Accuracy Coach: who corrects any mistakes in another member's explanations or summaries.
e. The Relater: who asks other members to relate current concepts and strategies to material studied previously.

Sometimes the teacher may ask each member of the team to complete a subtask such that all team members contribute to complete their task. Such task specialisation (when assigning specific roles or tasks to group members) provides all team members with the opportunities to practice cooperative skills.

5.7 How should the Implementation of Cooperative Learning be Started?

Since it is the first time that students will apply cooperative learning in their class, it is very important for the teacher to decide how to begin with the students. The teacher may begin with a philosophy statement to introduce statements to encourage the students to accept the changes that will happen (Dees, 1990). For example, " We are going to have a pleasant, fun, interesting and constructive learning environment". Or, " We always use traditional methods in teaching and learning mathematics, we meet some difficulties in understanding the material, solving problems and dealing with mathematical applications. Let us try to use another method which is called cooperative learning that includes attractive, competitive, knowledgeable, enjoyable and active strategies in learning mathematics".

The teacher may explain to the students that research shows the method to be effective and, since students face some problems in the mathematics classroom, the researchers found that these strategies address many mathematical problems in different ways.

The teacher describes to the students the strategies they will use during the implementation, the roles for the students, how to cooperate and how to participate to master the material. He/she must explain to them how to share materials, help each other and work as a team with specific goals. The teacher encourages the students by reminding them that they may earn certificates or other reward based on their teams' total performance. He/she must not forget to remind the students that each one of them is responsible for mastering the material and for understanding the assignment and the problem solving. That means that all students must keep in mind that they are individually accountable; this may be measured by individual quizzes or by selecting a team member randomly to represent his/her team (Dees, 1990).

After the teacher has decided the size of the groups, the number of the groups and has assigned each team member to a group, the teacher asks the students to help him/her to arrange the room, physically. Each group member presents their name to their team's members and each team will choose a name for their team. The first day is usually the most difficult day but, when students feel happy and are interested, they will forget all the effort that had been made and they will be pleased to try a new experiment.

The teacher asks the students to prepare their materials and instruments and put them together in the middle of the table or the desks such that all team members can use them freely. These materials include pens, pencils, rulers, rubbers, colours, scissors, paper, calculators, and so on. In fact, the materials depend on the lesson itself.

Each student must have his/her textbook and his/her own writing book to record the notes so that it will easy for him/her to return to the material that has been studied and to the problems that have been solved, or in order to document the correct answer after introducing feedback.

The teacher discusses with the students the strategies that will be used during the cooperative leaning, she/he presents to them a form for the teams' scoring table (by using the OHP) and discusses the methodology for the teacher to complete this table. They may decide to make a notice-board to report on it the best team and the leader for each team in every week's quiz in such a way that the results will be obvious for the whole to the class (Artzt and Newman, 1997).

5.8 How should a Cooperative Problem-Solving Lesson be Taught?

The cooperative lesson is divided into three major parts. First of all, the teacher presents or reviews concepts that are needed to present the lesson, explains the academic task, the problem that must be solved to understand it and to understand the scope of the solutions possible, and the guidelines which are necessary to record their results, and explains to them the assignment task to be completed by the group **(group goal)**. The teacher poses a problem which is similar but smaller than the problems that the students are expected to solve, explains the steps for solving the problem and checks that the students understand the explanation (Burns, 1990).

The introduction to the lesson is a very important part because, if the teacher is able to focus the students' attention on the lesson, they will feel interested in their study. It is very important for the teacher in the mathematics class to try to relate the objectives of the lesson to daily life situations and make a connection between the mathematical concepts, theories, roles, facts, principles, algorithms and problem solving with real life applications, as much as possible.

Sometimes the introduction for the lesson may be quite different. If the purpose of the teacher is to guide the students to find out by induction a mathematical generalisation, fact or theory, the teacher may give each group an assignment, work sheet or a task and ask them to solve it step by step. He/she may give each member of the group a subtask **(task specialisation)** to be solved and all the members of the group will cooperate to reach the answer that they are searching for and to complete their task.

The second part of the lesson, after the problem has been introduced, is the exploring and the group working (Johnson and Johnson, 1990; Terwel, 1990; and Burns, 1990). The students work cooperatively toward a solution and, while the group members are working cooperatively, the teacher must monitor the students' work, observe the interaction between all team members and listen to their ideas, strategies and procedures for solving the problems (Reid, Forrestal and Cook, 1989). She/he may offer help for the students when it is needed if none of the members of the group can solve the problem or are not working (Burns, 1990). He/she may ask them some questions to lead them to the solutions, such as: What are you doing? Why are you doing it? How will it help? What about trying to...? The teacher provides students with assistance to understand the process for solving the problems and encourage them to work cooperatively to master the common goal.

If any group finishes early the teacher may give them additional activities. While group-working, the teacher must always remind the students to work cooperatively such that all the class members learn the assigned material and encourage them by providing **group rewards.** The teacher's praise and a smile may be enough, or a smiling-face sticker may be better. A hand made certificate can be a reward to the winning group at the end of the week. Applause should follow the presentation of the reward and the group's name should be placed on the bulletin board for all to see (Artzt and Newman, 1997). Also, the teacher must ensure that the students understand that they are **individually accountable** for completing the assignment.

The third part is the reflection, evaluation and processing. This part takes place at the end of the lesson following the group work. The results and the actual processes of the group work are discussed in the class to evaluate students' learning and to give feedback. The teacher must specify the different ways of solving the problem and of various solutions, use questions to investigate other ways of handling the problem and, sometimes, guide the students to generalise some facts or roles from the solutions (Johnson and Johnson, 1990; Terwel, 1990).

At the end of every week each student takes an individual quiz to solve alone without helping one another to ensure that every student is individually responsible for knowing the material **(individual accountability).** This quiz is designed to test the knowledge gained from the class presentation and during team practice. The scores of the students are recorded in their group weekly report (fig. 5.2) and the average group score is computed and recorded on that report. The students in the high performance team will have a certificate or other reward **(team competition and group reward).** These procedures will be repeated every week and at the end of each unit. All the class groups revise by working a worksheet cooperatively and, after finishing the work sheet, tournaments may take place between the different teams' members to compete against others (Slavin, 1990a). The competition will consist of three parts.

- High-achieving students against others with similar past records in mathematics.
- Middle-achieving students against others with similar past records in mathematics.
- Low-achieving students against others with similar past record in mathematics.

The winner of each tournament table brings points to his/her team which means that low achievers and high achievers have equal opportunities for success **(equal opportunities for success).**

After that, all the class take an individual mathematics examination on the whole contexts of the unit to examine their understanding of the materials. The students in the high performance team may add extra points to their exam scores as a reward for their work as a team.

5.9 How a Mathematical Lesson should be Adapted for Use of Cooperative Learning Groups?

Applying cooperative learning mathematics lessons needs good preparation of materials used in implementation. Weissglass (1979) in his book *'Exploring Elementary Mathematics'* provides mathematics teachers with a wonderful book which gives guidance in how to plan for, and implement, cooperative learning mathematics lessons in different fields and branches of mathematics. Because of:

- the lack of provision in the Jordanian curriculum of examples of activities and lessons for the use of cooperative learning mathematics lessons
- the non availability of resources for teachers to help them to adapt a mathematics lesson for the use of cooperative learning

the researcher prepared some models of samples and activities that can be used in cooperative learning mathematics lessons. The contents of the subject involved in the those examples are from the Jordanian mathematics curriculum in the eighth grade (Ministry of Education- Jordan, 1994). The researcher planned for these activities in order to use them in the training programme for teachers in how to use cooperative learning in the mathematics classroom. The examples are different types of cooperative mathematics lessons (problem solving, developmental lessons and homework review (see appendix eight)).

5. 10 Conclusions for Research Construction and Practice

The contents of this chapter present the developmental implementation for the use of cooperative learning in the mathematics classroom. It addresses several issues that must be highlighted in the training programmes to apply cooperative learning strategies in the mathematics classroom, effectively, such as:

- informing teachers about the real meaning of cooperative learning and its principal components;
- why, when and how to use cooperative learning;
- how to apply cooperative problem solving lessons;
- teachers' roles and decisions;
- how to adapt a mathematics lessons for the use of cooperative learning.

This study differs from other previous studies in several aspects.

1. Providing teachers with an in-service training programme.

Applying cooperative learning in the mathematics classroom requires a different approach to planning and teaching than traditional instruction. Hence, there was a need in this study to provide teachers with such programme with a good framework for effective implementation. The training programme addresses several issues that have been mentioned previously.

2. Developing the model of implementation in the mathematics classroom.

The literature reviewed many opportunities for using cooperative learning in the mathematics classroom; problem solving lessons, developmental lessons, enrichment activities, and test and homework review. On the other hand, as was presented in the previous chapter, there are different cooperative learning methods. The model of implementation modified by the researcher is a developmental one that is a mixture of different strategies that can be used for several types of mathematics lessons. The strategies are a mix from Student Teams-Achievement Divisions (STAD) that is used as a basic and general design for mathematics lessons with a mix of strategies from Group Investigation, Learning Together, and sometimes a form of Teams-Games-Tournaments (TGT) for the use of different types of problem solving lessons, developmental lessons, enrichment activities, or for the test/ unit / homework review, where the teacher is responsible in how to apply these strategies.

3. Providing teachers with a sample of activities and lessons that is adapted for the use of cooperative learning mathematics lessons.

The contents of the mathematics material are from the Jordanian mathematics curriculum for grade eight and the researcher adapted these activities and lessons for the use of cooperative activities in mathematics lessons.

Chapter Six

Perspectives of Classroom Research

Chapter Six
Perspectives of Classroom Research

6. Introduction

The relationship between the teaching and learning process is a complex one. No one can separate one of the factors that interact together to form the students' outcomes. Many studies highlighted the importance of the elements that work together to complete a specific task. Here the work attempted to be achieved is to increase and improve the students' performance and achievement outcomes and the field of their social and behavioural interaction between the students' themselves.

In this chapter the researcher discusses most of the factors that influence the learning and teaching process, especially in mathematics. The researcher also discusses how to design an experimental developmental programme for the purpose of the study for using cooperative learning as a progressive teaching method. Also, the researcher describes how to implement her programme in a good way taking note of the factors that influence the learning and teaching process. Finally, she presents the methods in how to evaluate her programme by using qualitative and quantitative evaluation methods.

6.1 Factors which Influence the Teaching and Learning Process

In order to study carefully the outcomes that are expected when applying an experimental method on the basis of assessing the effectiveness of one factor (that is the teaching method), it is very important to look out for all other factors that may play roles in the teaching and learning process. Many studies present several types of factors that form several phases. Cooper and Dunne (2000) in their book, *'Assessing Children's Mathematical Knowledge'* pointed to some problematic variables such as ability, social class, gender, ethnicity, language and cultural resources. Terwel and Eeden (1992) pointed to the effect of curricula. Cocking and Chipman (1989) highlight the effect of the language on learning mathematics. Hawley et al. (1984) referred to the effect of students' ability and personality, teachers' characteristics and personality and to the effect of motivation on students' outcomes. In addition, Hill (1982) and Webb (1982c, 1989 and 1991) discussed the individual differences of ability, sex and affiliation that effect student performance. Hoek, Terwel and Eeden

(1997) pointed to at least two theoretical orientations that explain the differential effects of the students within their heterogeneous groups: sociological and cognitive. Moreover, Boaler (1997) mentioned other factors which may influence the "day-to-day experiences" in classrooms and characterised them as both traditional and progressive. These factors are: setting and mixed ability teaching, gender, learning style, different teaching approaches which influence the nature of knowledge that students develop and the ways that students approach new situations.

These factors can be summarised as the following:

1. students' ability;
2. teachers' characteristics and teaching skills;
3. gender differences;
4. ethnicity;
5. language;
6. social class;
7. curriculum;
8. motivation;
9. classroom management;
10. teaching method.

6.1.1 Students' Ability

A wide variety of differences between students will be observed when they have been asked to do mathematics (Orton, 1992). These differences relate to their abilities. Postlethwaite (1993) classified the differences in students' ability: educational, psychological, physical and others, such as social, within the classroom activity. Orton (1992) tried to answer the following question, Why do some pupils achieve more than others? In his answer, he backed several reasons, such as, individual differences, convergent and divergent ability, mathematical ability, spatial ability, gender-related differences and, finally, references and attitudes. Also, Charles and Lester (1984) outlined several mental processes that are involved in successful problem solving, such as experience factors which include previous mathematics background, familiarity with solution strategies and familiarity with problem context and content. Moreover, he pointed to other cognitive factors that usually play a role, like reading ability, reasoning ability, computational skills, memory, analytical ability and logical ability. In fact, recent research studies of cooperative learning in mathematics pay attention to the individual differences between students and their responses to the demands and opportunities of that form of instruction. (Peterson and Janicki, 1979; Mulryan, 1992).

This present study has been designed and implemented on mixed ability classes. In Jordan, students in their classes are classified according to their final scholastic year test scores. Each class contains students at low, middle and high performance levels and, of course, since students in their classes are chosen randomly, the previous characteristics in the students differ from one student to another. However, a very important issue in this present study is that the researcher searched for students' progress within the year of the experiment and, therefore, it is not necessary to choose equivalent classes in our sample of the study. Moreover, the qualitative analytical part of this present study, including the interviews with students and teachers and the teachers' weekly diaries, highlight how this factor might influence the learning process.

6.1.2 Teachers' Characteristics and Teaching Skills

The teacher is the key person who presents the lesson, discusses the algorithms and the procedures, gives the examples, interacts with his/her students, evaluates them and presents feedback to solve their problems and to promote their learning.

One factor which may influence the teaching and learning process is the teacher's personality and characteristics; for example, years of teaching experience, number of mathematics courses taken and personality traits like enthusiasm and his/her teaching skills (Hyde, 1989; Koehler and Grouws, 1992). Before 1950 most research presented work on teacher effectiveness, teacher characteristics, teacher behaviour and teacher personality traits with little or no attention given to other factors or to the quality of teaching (Koehler and Grouws, 1992) and it was found that the teachers' characteristics directly affected students' outcomes. At that time this level of research was described as level one of the research model. Later on, several studies paid attention to factors that play together with teacher characteristics, such as pupils' characteristics, pupils' attitudes toward mathematics and themselves, teachers' attitudes, teachers' beliefs about teaching and mathematics, teacher knowledge of content, pedagogy and student learning. The last factors interact within the classroom process between teacher behaviour and pupil behaviour and affect directly on the students' outcomes in the cognitive and affective fields. This level of the research model was classified as level four during the development that occurred in such research and studies (see Koehler and Grouws, 1992, p.118, figure 6-5, level four - research model). This diagram explains the last level of the research model.

Teaching skills in how to plan a lesson, how to implement it and how to evaluate the students' outcomes are major factors in the learning and teaching process. All moves that are done by the teacher during his/her lesson implementation play a role in enhancing the learning. So, it is difficult to separate the model of instruction from the teaching skills because both are partners in the learning process.

Recent research has taken place and is centred on the constructivist approach. One way in which research on teaching has been linked with research on learning is through a constructivist perspective (Cobb et al,1991). One of the research techniques is the teaching experiment.

> " Researchers worked closely with an experienced but traditional teacher to develop instructional activities that allowed students to construct their knowledge of important mathematical ideas and concepts".
>
> (Koehler and Grouws, 1992).

When applying an experimental research programme to assess the effectiveness of a new teaching approach (here that is cooperative learning) on students' achievement, it is very important to train teachers in how to implement teaching strategies by using a new method and to develop the skills they need to work more effectively (Reynolds, 1994). This training must be prepared well and take enough time in order to encourage the teacher to apply the new teaching method, present him/her with a good framework to be implemented and, finally, enable the teacher to assess the weakness and the strengths of applying such a new method and evaluate its outcomes in a correct way. Such training programmes affect directly on teachers' beliefs, characteristics and attitudes and, in this case, teachers have the benefit of some introductory in-service training (Button, 1981). Therefore, this type of training is considered as professional development for the teachers.

It is expected that

> " pre-service teachers will teach what and how they are taught" Also " pre-service teachers knowledge base and beliefs about teaching and learning also affect the content of a methods courses as well as the type and number of field experiences that need to be required"
>
> (Vacc and Bright, 1994, P. 119).

Therefore, there is a need to provide teachers with in-service training programmes the content of which should include a mathematics methods course and how it should be presented.

The author recognises that teachers who have been trained in how to use cooperative learning strategies may be strongly motivated by the new method. They may be more enthusiastic in applying the new strategy than those using traditional approaches. In order to minimise this problem as far as possible, the teachers in the experiment chose to provide a balance according to their qualifications, number of years of experience and their gender.

6.1.3 Motivation

Much research that has been undertaken has something to do with motivation. The topics of this research deal with achievement motivation, social motivation, extrinsic versus intrinsic motivation, the need for achievement, and so forth (Shaughnessy, 1992). In spite of that, Shaughnessy (1992) commented that:

> "according to Mandler (1989), part of the problem is that there is still no framework for research on motivation that fits comfortably into current research in cognitive psychology."
>
> (Shaughnessy, 1992, P. 586).

No one can ignore the effect of motivation on students' performance. Reinforcement has always been an important part of teaching methods. It is mostly based on fear. For example, fear of incurring the wrath of the teacher or fear of punishment (Orton, 1992).

Positive effects can be expected on the basis of motivation theory (Terwel et al, 1994; Hattie, Biggs and Purdie, 1996). Also, Orton (1992) pointed out that learning in order to gain a reward, like gold stars, house points, merit marks, praise and encouragement from the teacher, can be a very good form of reinforcement that motivates students to learn and to work.

Research proved that cooperative learning enhances the motivation theory because it focuses primarily on the reward or goal structures under which pupils operate (Slavin, 1990a). Also, Johnson and Johnson (1987) found that the research demonstrates that cooperation is much more facilitative of motivated effort and achievement than is competition.

6.1.4 Classroom Management

Classroom management is one of the most important factors that directly affect students ' and teachers' performance. If teachers and students were comfortable, interested and confident in their classroom during the teaching and learning process, good results may be expected. Managing the classroom is an initial step towards the more important goals that relate to cognitive and affective learning. Johnson and Johnson (1987, p. 165) pointed to this factor and stated

> " within most traditional classrooms there are students who are resistant to teacher influence, unmotivated to learn what is being taught, non-responsive to the usual reward teachers have to offer for appropriate behaviour, and inappropriately aggressive, hostile, obstructive, irritating and disobedient."

In addition, he mentioned that, in such classrooms, some students may be isolated because of their shyness, depression, or negative self-attitudes, or because some students may dislike others. To minimise these problems and try to control the students with different characteristics, cooperative learning groups are suggested to be implemented. This can be achieved within the classroom teaching and learning process by enhancing the interaction and giving positive interpersonal relationships characterised by mutual liking, positive attitudes toward each other, mutual concern, friendliness and attentiveness.

The environment of the classroom, its size, the number of students, the type of furniture, the teaching tools and instruments, and other things available inside the classroom, are important factors. A good teacher is one who can solve his/her problems inside the classroom, manage it, control it and offer a comfortable atmosphere for him/her self and for his/her students, too.

6.1.5 Sex and Gender Differences

Recent research and studies indicate that there is a gap between male and female students' mathematics achievement. Research findings are usually presented in terms of gender, either because of concern with equality of opportunity or because of beliefs concerning gender differences in cognitive predisposition. Actually, there is a basis of assumptions about the way in which boys and girls typically differ from each other, either in the cognitive predisposition or cultural identity (Cooper and Dunne,2000).
Drzewiecki and Westberg (1997), in their study, administered a survey to high school students to search for how students' attitudes towards mathematics differ by gender and by the grouping techniques used for mathematics instruction. The survey examined the impact of cooperative grouping as an alternative to traditional mathematics instruction for improving females' attitudes toward mathematics. The results of this study suggested that cooperative grouping may not be as advantageous for females as is traditional instruction for promoting positive general attitudes towards mathematics. Also, it may not be a better method for helping female students to gain greater confidence in their mathematics abilities.

Many studies have concentrated on that aspect. For example, Owens and Straton (1980) found that statistically clear and significant differences exist between the preferences of male and females over the range of grades from fourth year to eleventh and that searching for the effectiveness of learning is the preference for a mode of learning, cooperative , competitive and individualistic.

In Jordan governmental schools are single sex schools. Some schools combine female and male students just from the first to the fourth primary stages. In this present study the female and male schools are separate. Despite that, this study searches to find if there are gender differences in students' achievement in mathematics when applying cooperative learning versus the traditional one. It assesses gender differences related to students' attitudes towards mathematics, students' opinion about teaching methods and some other external factors that may influence the learning process. This makes sense because the two schools (female and male) have approximately the same conditions and circumstances as most Jordanian schools. The female and male students are from the same grade and approximately the same age. They are taught the same contents of the mathematical Jordanian curriculum.

6.1.6 Ethnicity, Language, Social Class and Curriculum

Several factors influence students' performance in mathematics as well as in other subjects. Ethnicity, language and curriculum are some of them. Also, cultural differences between students from differing social classes might influence their success and failure in mathematics (Cooper and Dunne, 2000).

- **Ethnicity and Language**

In this present study all students and teachers involved in the experiment are from the same ethnicity; they are from Arabic origins. Most of them are Jordanian. Their language is Arabic. It is the first language inside and outside schools. The curriculum is directed by the Ministry of Education. The same topics must be learned, finished and evaluated within the academic year. That means all of these factors are fixed in this study.

- **Social Class**

Of course it is impossible to say that all students are equal in their social classes. This factor is related to many components, such as parents' cultural and educational level, the economic standard, and so forth. However, a special part of the questionnaire is used to measure the effects of this factor; also, within the interviews with teachers, the researcher highlights this issue.

- **Curriculum**

Terwel and Eeden (1992) highlight the relationship between curriculum implementation and student learning. Terwel et al (1994) also mentioned that cooperative learning cannot be effected unless two aspects are considered: the instructional strategies and the content of the curriculum, and the composition of classes and groups.

It is really so difficult to control all the previous factors, but the researcher takes into consideration the effect of these factors in analysing the data collected in this research and how it might affect on students' outcomes.

6.1.7 Teaching Method

This factor is the basic one in this study which is designed to assess the rationality for using cooperative learning in the mathematics classroom and the effectiveness of using cooperative learning strategies as an alternative to traditional mathematics instruction on students' achievement and, in addition, to explore its effectiveness in promoting problem solving skills in mathematics. Many studies draw attention to using cooperative learning, especially in mathematics, which have been mentioned in previous chapters especially in chapter four. One of these findings related to Johnson et al (1981) in their 122 studies in assessing the effects of cooperative, competitive and individualistic goal structures on achievement. These studies generalised 286 findings; some of them indicated that cooperative learning is more effective than competitive and individualistic efforts, that cooperation with inter-group competition is superior to interpersonal competition and individualistic efforts and that there is no significant difference between interpersonal competitive and individual efforts.

6.2 Designing, Implementing and Evaluating an Experimental Research Study

Cohen, Manion and Morrison (2000) pointed out some design issues for planning the research. These include: the general aims, the purpose of the research, specific aims, questions, design, methodology, instruments, sample of the study, time frames, resources required, validity and reliability, data analysis, and reporting and writing up the research. This research study is an experimental one, so it is worthwhile to determine the variables of the research, including the independent and dependent variables (Cohen, Manion and Morrison, 2000). However, within the context of this study, the researcher discusses in detail all of these issues in different chapters of this thesis. Within the introduction of the thesis (chapter one), the researcher indicated the importance and need of the study, determines the objectives and aims of the research and specifies the questions to be answered within the research. The methodology of the research is discussed in detail in the next chapter, including the design of the study, the sample of the study, variables of the study, the time scale of the study, the research questions, the null hypothesis that the research findings will prove or disprove, the research instruments and the procedure of the study where the validity and reliability are considered within the research methodology. The resources required had been collected either to review the literature or to collect the research data to be analysed. The analytical stage is discussed in detail in chapter eight of the study. The conclusion of the research is presented in the final chapter with several recommendations. All of these issues complemented each other to form the present research.

Assessment and evaluation for experimental research need to be studied: how to design, implement and evaluate such research. The contents of the following subsections highlight basic issues in designing, implementing and evaluating an experimental research study.

6.2.1 Designing Experimental Research

The first and obvious reason for designing a programme of evaluation or assessment is to ensure a well-organised evaluation study and that all the right people will take part in the evaluation at the right time. Basically, a design is a way of gathering comparative information so that results from the research being evaluated and assessed can be placed within a context for judgement of their size and worth. (Fitz-Gibbon and Morris, 1978b). The collected data might have described the atmosphere within the classroom and how the classroom environment might have looked. It might have measured the progress of the students' performance within the experiment and how they participate. The research might search for students and teacher's judgement about teaching methods, about attitudes and about their perspectives and beliefs as outcomes expected from the designed study. This present study explores all of these issues to assess empirically the effectiveness of applying cooperative learning strategies versus the traditional methods in promoting problem solving skills and achievement in mathematics and to examine the rationality for the use of cooperative learning in the mathematics classroom.

Usually, a design accomplishes its objectives by prescribing that the measurement instruments be administrated to compare between groups involved in the experiment. Several researchers pointed to the efficiency of the triangulation that strengthens the study by combining methods. This involves using different kinds of methods for collecting data by using quantitative and qualitative approaches(Brannen, 1992; and Robson, 2002).

Robson (2002) identified the benefits of using multiple methods in the reduction of inappropriate certainty or to be used in a complementary fashion to enhance interpretability. Moreover, he pointed to the fact that the complementary purposes can be used to assess the plausibility of threats to the validity of the primary research technique used where using different methods enhances the validity of the research conclusions.

(Brannen, 1992) commented that multiple methods (method triangulation) may be used 'between-methods' or 'within-method'. 'Within-method' is involved when one method or instrument is used for different occasions while 'between-methods' means using different methods or instruments for the same object of the study. This present study intends to involve the triangulation by using different quantitative and qualitative approaches. These include pre-test / post-test, questionnaire, interviews, observations and diaries. However, table 8.1 in chapter eight (data analysis and discussion) summarises the use of these instruments to achieve the research aims and to answer its questions by analysing the data collected by these instruments.

Fitz-Gibbon and Morris (1978b) commented that the elements of the design form a plan to state what will be measured and when. Therefore, the basic elements of design are the group and times. A group of students means those students who all get the same programme or treatment. The experimental group consists of students who receive the experimental programme. The second element is time; times at which measurements are made. The time during this experiment expands for two semesters in order to assess the students' progress in mathematical performance and in their abilities in solving problem skills. However, the sample of the study (the group) and the time scale of the research fieldwork are discussed in detail in the next chapter.

6.2.2 Implementing Experimental Research

In implementing an experimental research study, the researcher should be concerned that the programme be implemented at its best and strongest. Therefore, a big consideration must be given to the materials used within the experiment, the methods of data collection, the bases of a good plan for constructing the research measures, such as tests, observations, questionnaires, and so on (Morris and Fits-Gibbon, 1978c).

The validity and reliability of methods and instruments used to assess research implementation and evaluation are important elements to help the researcher to determine the amount of faith people should place in its results. (Morris and Fits-Gibbon, 1978c; Cohen, Manion and Morrison, 2000; and Robson, 2002).

Cohen, Manion and Morrison (2000, p.105) commented that:

> "Validity is an important key to effective research. If a piece of research is invalid then it is worthless. Validity is thus a requirement for both quantitative and qualitative/ naturalistic research.... in qualitative data validity might be addressed through the honesty, depth, richness and scope of the data achieved, the participants approached, the extent of triangulation and the disinterestedness or objectivity of the research. In quantitative data validity might be improved through careful sampling, appropriate instrumentation and appropriate statistical treatments of the data."

The validity of the instruments means whether the instrument is an appropriate one for describing and measuring what the researcher wants to know about the study and whether a particular instrument, in fact, measures what it purposes to measure (Cohen, Manion, and Morrison, 2000). The description of the research, which the instrument presents, must be accurate, relevant, representative and complete. (Morris and Fitz-Gibbon,1978c; and Abu-Zena, 1998).

The reliability of the instruments answers the question that asks if the instrument produces consistent results or not. Reliability refers to the extent to which measurement results are free of unpredictable kinds of error. Actually, it is necessary to ensure that instrumentation, data and findings should be controllable, predictable, consistent and replicable. (Cohen, Manion, and Morrison, 2000).

In such an experimental research study, the researcher is concerned to implement this research at its best and strongest, in order for it to be implemented effectively in such a way to be able to achieve the research aims and answer its questions. Consideration is given to all materials used within the experiment, the research methods, the research instruments, the research design and when, how and why to use these instruments within the implementation of the research. The methodology of the research is presented in detail in the next chapter with a clear explanation of all issues which should be considered within the research.

Applying new research comes into existence because someone (the researcher or others) has in their mind a set of goals that the researcher/others intends to accomplish. The goals may be general or specific ones. The researcher must state clearly his/her goals and he/she can arrange them as a tree, from its roots to its branches. After that, the researcher puts his/her research questions to be answered according to his/her goals and objectives and may form a null hypothesis that may be proved or disproved related to the research findings and results.

This present study intends to assess the effectiveness of cooperative learning strategies versus traditional teaching methods in promoting problem solving skills and achievement in mathematics. Also, the study examines how teachers can best be trained to use cooperative learning strategies to be implemented effectively, to analyse the views of teachers and students on the use of cooperative learning and to evaluate the general developmental progress of students involved in the experiment. All of these aims examine the rationality for using cooperative learning in the mathematics classroom. The following subsection introduces several instruments which could be used in assessing and evaluating an experimental research study that is used within this research. As has been mentioned previously, this present study uses multiple methods that produce quantitative and qualitative data.

6.2.3 Evaluating Experimental Research

Clear planning of research goals and objectives is the first component of good evaluation and assessment. Educational research is intended to achieve goals. The major questions addressed during the evaluation of educational research are: To what extent were goals attained? What actually took place when the research was carried out? (Morris and Fitz-Gibbon, 1978b).

Hertz-lazarowitz (1992) identified six mirrors which reflect the learning situation in the traditional and cooperative classroom: the physical organisation of the classroom, the learning task, the teacher's instructional behaviour, the teacher's communicative behaviour, the student's academic behaviour and the student's social behaviour. In order to look at these mirrors many instruments must be well prepared and used during the research implementation. These form the tools for collecting data to be analysed needed for an assessment of the effectiveness of applying an experimental research study.

A discussion of different research instruments used within this present study is now presented.

- **Achievement Tests**

Evaluating achievement objectives in such research needs procedures and rules of thumb for performing evaluation tasks related to measuring achievement and needs some of the theory underlying the procedures for developing and selecting achievement tests and interpreting their results (Morris and Fitz-Gibbon, 1978a).

Cohen, Manion and Morrison (2000, pp. 321-334) commented that the construction of a test needs careful consideration on order to:

1. identify the purposes of the test
2. identify the test specification
3. select the contents of the test
4. consider the form of the test
5. write the test items
6. consider the layout of the test
7. consider the timing of the test
8. plan the scoring of the test.

Moreover, he highlights, in such experimental research, the need for consideration of devising a pre-test and post-test and the need for the reliability and validity of the test.

Tests given before an experiment starts are called pre-tests. Similarly, tests given at the end are called post-tests. This research is experimental and used the pre-test /post-test design. Constructing the achievement tests needs specific procedures and rules in order to ensure that it really measures the students' achievement. In order to build up the achievement tests, it is better at the beginning to identify the objectives of the test. Morris and Fitz-Gibbon (1978a, p.13) identified that issue and stated the need

> " to ensure that the test covers the constructs' major manifestations or adequately represents curricula in widespread use. The test developers survey the subject content and arrive at a range of cognitive or affective behaviours that can be formed into test items. A content/process matrix is frequently used to organise survey of possible kinds of items and to focus attention on how many items- and therefore how much weight- should be assigned to each sub-area of the construct. "

Morris and Fitz-Gibbon (1978a, p. 25) described Bloom's (1956) classification of educational goals in the cognitive domain. The classification included six degrees, from simplest to most complex, to which information that is taught can be learned. An annotated cognitive domain taxonomy was stated as:

> "**1. Knowledge:** Recalling information pretty much as it was learned; **2. Comprehension:** Reporting information in a way other than how it was learned in order to show that it has been understood; **3. Application:** Use of information to solve a problem; **4. Analysis:** Taking learned information apart; **5. Synthesis:** Creating something-new good based on some criterion; and **6. Evaluation:** Judging the value of something for a particular purpose."

Since the basic aim of this study is to assess the effectiveness of cooperative learning strategies on promoting problem solving skills and achievement in mathematics, pre-test / post-test achievement and problem solving assessment had been designed, developed and implemented. The next chapter discusses in detail procedures followed for these instruments.

- **Questionnaires**

Questionnaires are widely used and useful instruments in collecting data (Cohen, Manion and Morrison, 2000). They present information to a respondent by writing or by using pictures in order to form the response either by a check, a circle, a word, a sentence, or several sentences (Henerson, Morris and Fitz-Gibbon, 1978). The use of questionnaires is wide spread in collecting research data because of their advantages (Henerson, Morris and Fitz-Gibbon, 1978; Cohen, Manion and Morrison, 2000):

1. they permit anonymity;
2. they give a person a chance to think before give his/her responding answer;
3. they can be given to a lot of people at the same time and with the same questions;
4. they are relatively cheap;
5. they are more easily analysed.

However, in spite of these advantages, they do not provide the flexibility of interviews and it is better always for people to express their views orally than in writing (Henerson, Morris and Fitz-Gibbon, 1978).

There are several types of questionnaire items. These include dichotomous questions, multiple choice questions, rating scales and open-ended questions (Cohen, Manion and Morrison, 2000). The questionnaire conducted in this research is a self-completion questionnaire focussed on closed rating scales questions for students involved in the experiment. This form of questionnaire has its advantages where it is quick to be completed and straightforward to code at the analytical stage but it does not enable the respondent to add more information, remarks, or qualifications (Cohen, Manion, and Morrison, 2000). However, this form of questionnaire was a suitable one in this present study where the students are the respondents and it is easy for them to complete such questionnaires. Moreover, there was no specific information needed about any categorisation where all students were from the same grade. The only categorisation was regarding gender and the type of teaching method involved in their classes. On the other hand, face-to-face interviews were conducted with a random sample of students for more open-ended questions that had been involved within the interviews (Robson, 2002).

Constructing the questionnaire needs good preparation. The basic process of operationalising a questionnaire can be summarised in the following ways (Cohen, Manion, and Morrison, 2000, p. 246).

1. Clarifying the general purpose of the questionnaire and then translating it into specific aims.

2. Identifying and itemising subsidiary topics that relate to its central purpose.
3. Formulating specific information requirements relating to each of these issues.

Designing a self-completion questionnaire needs consideration when constructing its questions to avoid problems in wording. Questions must be clear, simple, short and easy to be understood (Robson, 2002).

Questionnaires conducted within this present study were designed with several aims and objectives. A detailed discussion for designing, developing and implementing this instrument will be discussed in the next chapter.

Interviews

An interview is a face-to-face meeting between two or more people in which the respondent answers questions posed by the interviewer. It is a flexible and adaptable method of investigating issues (Robson 2002). This method has several advantages because it can be used to obtain information from people who cannot read or from people who may have difficulties with the wording of questionnaires. A higher response rate is obtained from group interviews than by using questionnaires. In addition, it is better than questionnaires for obtaining more information and ideas that require sequencing (Henerson, Morris and Fitz-Gibbon, 1978; Robson, 2002). There are, however, some disadvantages in using this method. It needs much time to be undertaken, especially if the group that the researcher has to interview is large, and sometimes the interviewer himself/herself may influence the respondent. So, using several methods of collecting data (questionnaires, diaries, observations and so on) is better in order to be on the safe side and to prevent, as far as possible, errors that may occurr by using specific kinds of measuring instruments (Cohen, Manion, and Morrison, 2000; Brannen, 1992; Robson 2002).

Cohen, Manion and Morrison (2000, p. 268) pointed to several purposes of using interviews:

" • to evaluate or assess a person in some respect;
- to select or promote an employee;
- to effect therapeutic change, as in the psychiatric interview;
- to test or develop hypotheses;

- to gather data, as in survey or experimental situation;
- to sample respondents' opinions, as in doorstep interviews."

Hence, and since one of the basic aims of this present study is to analyse the views of students and teachers on the use of cooperative learning versus traditional teaching methods and to assess its effectiveness in promoting students' mathematical achievement and problem solving skills, it was useful to conduct interviews with them to achieve these aims.

There are different kinds of interviews. These include full structured interviews, semi-structured interviews and unstructured interviews (Robson, 2002). The semi-structured interviews are one of the most widely used data collection methods in educational research because, although it has predetermined questions, the interviewer can get more explanations, investigations and in-depth views where question wording can be changed and explanations given through a sequence of questions within open discussion. This type of interview in the present study is useful to be conducted in such a way to raise questions such as 'why' and 'how'. Hence, it allows the researcher to explore and investigate the reasons behind respondents' responses. Robson (2002) pointed to the advantages of the use of open-ended questions within the interviews. They

"

- are flexible;
- allow you to go into more depth or clear up any misunderstanding;
- enable testing of the limits of a respondent's knowledge;
- encourage cooperation and rapport;
- allow you to make a truer assessment of what the respondent really believes;
- can produce unexpected or unanticipated answers."

Kvale (1996) addressed seven stages for planing interview-based research procedures.

1. Formulating the purpose of the investigation and identifying the concepts of the topics to investigated.
2. Planning the design of the study with consideration to all seven stages of the investigation before conducting the interviews.
3. Conducting interviews.

4. Transcribing the interview material from oral to written form for the need of the analysis.
5. Analysing the data collected on the basis of the purpose and topics of the investigation, and on the nature of the material of the interview.
6. Verifying the generalisability, reliability and validity of the interview findings.
7. Communicating the findings of the study and the methods applied to form the final results in a readable product.

Two types of interviews were conducted in this research with students and teachers involved in the experiment. There were several objectives under specific topics for conducting such interviews. The next chapter highlights the design of these instruments and how it has been implemented.

- **Observations**

Observation procedures are usually used to record what has been seen and heard within a number of observations that have taken place during a specific period of time within a course or programme. It is a detailed description of what has been done. It can be recorded by questionnaires, rating scales, or tally sheets. This instrument has its advantage in collecting the information and directs the observer's attention to peoples' behaviours within a course or programme. Robson (2002) highlights the advantage of using observations as being its directness to be used for assessment of the effectiveness of a research study. Moreover, he considered that this method could be used as a complementary one to information collected by other techniques and it is the most suitable data collecting method 'for getting at real life in the real world'.

Morrison (1993, p.80) commented that this instrument enables the researcher to gather data on:

> " (1) the physical setting of schools and classrooms (e.g. the layout of the school and classrooms, resource organization, groupings of children and teachers);
> (2) the human setting of schools and classrooms (e.g. gender, racial, ability factors);
> (3) the interactional setting of schools and classrooms (e.g. the interactions - formal, unplanned, and non-verbal – of children, teachers support services, headteachers);

> (4) the programme setting of schools and classrooms (e.g. resources available, teaching and learning styles and their uses, curriculum content and organization)."

For that reason it was useful to use such data collecting instruments for collecting data to record to what extent the experiment was applied and what the general teaching and learning skills in the two experimental groups are, including: introduction, reflection, evaluation and processing, group management, instruments and materials, students' group work and interaction and classroom management.

Some of the disadvantages of using this instrument are that it takes time and sometimes the people may be uncomfortable when they feel that they are observed by somebody else. (Henerson, Morris and Fitz-Gibbon, 1978; Robson, 2002). However, the researcher was aware of this point which allows teachers to work confidently in their classes where anonymity is considered important within the research. Moreover, they were informed that these observations would be used for the use of the research needs only.

Lesson observation conducted by the researcher was vital to evaluate to what extent the experiment was applied and what the general teaching and learning skills in the two experimental groups were. The use of such instruments is discussed in detail in the next chapter of this study.

- **Diaries**

Diaries are a self–reporting instrument that describe activities, experiences and feelings within a programme. They are often written on a daily or weekly basis. Although this type of instrument can provide a wealth of information about person's experience or feelings, there is a problem in extracting, categorising and interpreting the information. So, it needs a big effort in preparation and analysing. (Henerson, Morris and Fitz-Gibbon, 1978). Robson (2002) gave basic notes for guidance in developing a diary form. These can be summarised in the following way.

1. Think of it as a questionnaire.
2. Because the diary involves self-completion of a series of forms, the researcher should ensure that respondents know what they have to do, when and why.
3. The researcher should be aware of how the items relate to the research questions and how they are to be analysed.

4. General consideration about confidentiality, anonymity, feedback of result and permission are applied.

To focus the attention of teachers on the behaviour and the attitudes of students in their classes (both experimental groups) and to assess their judgement about the general developmental progress of students involved the experiment, teachers had been asked to record weakly diaries of students during the experiment.

This present study is rich with several research instruments that are designed by the researcher for the need of the study to achieve its goals and to answer the research questions. The research instruments are various, including pre- and post-achievement tests, questionnaires, interviews, weekly diaries and observations. Designing, developing and implementing the research instruments used within this research are discussed in detail in the next chapter.

After data had been collected the researcher began the analytical stage for the quantitative and qualitative data collected. There are different statistical techniques and tests which could be used for the quantitative analysis. The researcher was aware of the need to choose the suitable ones for the design, the variables and the objectives of the research and the instruments used to achieve these aims. A detailed explanation for the quantitative data analysis and the techniques used for the pre-test / post-test and the questionnaire is discussed in detail in the following chapter. Interviews, observations and diaries were used for the qualitative part. Data collected had been analysed qualitatively, as will be discussed in the next chapter, too.

6.3 Conclusions for Research Construction and Methodology

The examination of the literature has demonstrated the impact of several factors that may affect the teaching and learning process. These include student ability, teachers' characteristics and teaching skills, gender differences, ethnicity, language, social class and curriculum. This study differs from previous studies because it explores the impact of all of these factors on the teaching and learning process.

The study is empirical research which needs a theoretical framework for designing, implementing and evaluating educational research variables needed for assessing the effectiveness of applying new teaching strategies in the mathematics classroom. The contents of this chapter relate to these issues starting from determining the research objectives and ending with research instruments. Moreover, the contents of this chapter form a base for the research methodology discussed in detail in the next chapter.

Several goals and objectives are measured and several types of measuring instruments used. There are variable inter-relationships between the research objectives and the measuring instruments. The researcher used the pre-test / post-test to assess student progress in mathematical knowledge and their abilities in solving problems. Also, a programme evaluation questionnaire, teachers' weekly diaries and the interviews combined to measure its goals to achieve this aim.

Because the sample of the study is quite large and there are many questions to be answered, the programme evaluation questionnaire covers many things. It consists of five parts. The first assesses student beliefs about the effectiveness of teaching methods on progress in mathematics and on problem solving skills. The second part explores student perspectives about mathematics teaching methods. The third part measures student attitudes toward mathematics. The fourth part searches for other expected non-academic advantages from applying cooperative learning as a developmental teaching method. Finally, the last part searches for other external factors which may influence the teaching and learning process.

Two types of interviews are conducted for all teachers and for some students' involved in the experiment. The student interviews explore many issues. They assess the effects of the teaching method on mathematics performance. Also, they explore the student' views of the effectiveness of the teaching method on their performance in mathematics and their ability in problem solving skills. Another goal of the interviews is to investigate students' attitudes towards mathematics and the teachers' experience and ability to use the teaching method. These interviews also help in searches for other non-academic achievement which may be expected and they investigate students' views about the advantages and disadvantages of using cooperative and traditional teaching methods.

The interviews conducted with the teachers involved exploring several aims. They investigate teachers' beliefs about the rationale for using cooperative learning strategies in teaching. They examine the effectiveness of teaching methods, especially cooperative teaching strategies, on students' mathematical performance and problem solving skills. The interviews evaluate the training programme conducted for cooperative teachers to train them in how to use cooperative learning in the mathematics classroom. Teachers' attitudes toward mathematics teaching are measured by such interviews. Also, the interviews explore teachers' judgement about students' activity, students' performance, students' interactions and behaviour within the group work. Finally, it searches for teachers' judgement about the advantages and disadvantageous of the different teaching methods.

The weekly teachers' diaries explore teachers' judgement about the students' progress within the experiment in their mathematical knowledge and in their ability to solve mathematical problems.

The researcher's observation sheet evaluates how teachers applied their mathematics lessons within the period of the experiment and concentrates on measuring teachers' mathematics teaching skills and students' behaviour within the traditional and cooperative classes. This study is unique in involving all of these research instruments.

The contents of the following chapter display the methodology followed within this present study to achieve its aims and to answer its questions.

Chapter Seven

Methodology of Research

Chapter Seven
Methodology of Research

7. Introduction

The research undertaken followed an experimental methodology in the mathematics classroom. Its objectives concentrated on assessing the effectiveness of cooperative learning strategies versus traditional ones in promoting problem solving skills and achievement in mathematics among Jordanian eighth basic primary stage students. This aim is the major one. There are some other objectives to this study, such as: to investigate how teachers can best be trained to use cooperative learning in mathematics; to analyse the views of teachers and students on the use of cooperative learning; to explore empirically the effects of teaching methods on students' attitudes towards mathematics and their outcomes in the non-cognitive domain; to investigate how cooperative learning might contribute to the broader development of students. In general, all of these aims lead to one purpose, that is to examine the rationality for using cooperative learning in the mathematics classroom.

Since there are other factors that may influence the teaching and learning process (as has been discussed in the previous chapter), this present study took note of factors other than the effect of the teaching method and, therefore, some instruments in data collection explore the effects of these factors, such as students' ability, teachers' characteristics and teaching skills, classroom management, motivation and the effect of the curriculum. In addition, gender differences are considered through all of the research stages.

Two instructional approaches were employed in the study. Cooperative learning is considered one of the new developmental teaching approaches which has not been applied in Jordanian mathematics classrooms. The other one is the traditional teaching method used in Jordanian mathematics classrooms. Two groups of teachers participated in the research: those who were trained in how to use cooperative learning strategies in the mathematics classroom and those who applied their usual traditional approach of teaching. Female and male students from the eighth upper basic primary stage in the Jordanian educational system formed the sample of the study in separate female and male upper basic primary schools.

The rationality and efficiency for using cooperative learning strategies in mathematics were tested quantitatively and qualitatively. In-service teacher training programme had been conducted for training teachers in how to use cooperative learning strategies in the mathematics classroom. Pre- and post-achievement tests and a programme evaluation questionnaire were used for quantitative data collection. The qualitative part was by conducting interviews with some students and all teachers involved in the experiment and by reporting observations and weekly diaries. The weekly diaries were reported by the teachers themselves while observations were conducted and field notes reported by the researcher herself during the class visits within her fieldwork.

In order to construct the methodology used in such experimental research study, the researcher reviewed the literature and, while the contents of the previous chapter highlight basic issues for designing, implementing and evaluating such experimental research study, the following sections in this chapter define and discuss the methodology used during the research study.

1. Design of the study.
2. Sample of the study.
3. Variables of the study (independent and dependent variables).
4. Time scale of the fieldwork.
5. Research questions.
6. Hypotheses for the study.
7. Research instruments development.
8. Procedure of the study.

7.1 Design of the study

The research undertaken used an experimental methodology; a group design in which the outcomes of cooperative learning are compared with traditional methods. The group design was composed of two experimental groups (A) and (B). Experimental group (A) consists of female and male students from the eighth grade (approximately 14 years old); those were taught the contents of the Jordanian eighth grade mathematics curriculum by using cooperative learning. Experimental group (B) consisted of female and male students from the same grade; those were taught the parallel contents of the Jordanian mathematics curriculum by using traditional methods. Two parts of research data collection and analysis were involved in the study: the quantitative and qualitative.

The quantitative part

1) Pre-test / post-test achievement and problem-solving skills assessment were designed by the researcher and developed to measure and assess the progress of the students within the experiment in mathematical achievement and their problem solving skills.

This part was analysed by using SPSS (Statistical Packages for Social Studies) to assess students' progress in mathematical achievement and problem solving skills. Questions in the tests were of different standards in the cognitive domain. This had been designed in order to assess the differences in students' mathematical achievement in questions of low-level of thinking and high-level of thinking and, hence, to assess their ability in problem solving skills. So, the test consists of two basic parts.

- First part: where questions are of the standard of knowledge and computations, and comprehension.
- Second part: where questions are of the standard of application and analysis.
- Total: general achievement.

Tests were conducted to assess students' progress at different levels of mathematical achievement before and after the experiment. The post-test was conducted as a dependent variable related to the effect of teaching method, gender and the interaction between teaching method and gender (as independent variables) and regarding students' initial mathematical abilities in the pre-test (as a covariance variable). Several types of tests were used. Multivariate Analysis of Covariance (MANCOVA) was used to assess any statistical differences between students' final achievement in the two experimental groups (Fitz-Gibbon and Morris, 1978a; Oqeili and El-shayeb, 1998; and Robson, 2002). Paired sample t test was used to assess students' progress before and after the experiment and to compare means (Oqeili and El-shayeb, 1998; Norusis, 2000 and Robson, 2002). Percentage of the success and failure before and after the experiment for students in the two experimental groups were also calculated to assess the progress of the students. The reliability coefficient was also calculated for the pre-test and the post-test by using the '*Kronbach alpha*' method to test the reliability of the two exams.

2) A programme evaluation questionnaire composed of five parts was designed by the researcher herself and developed for specific objectives. These five parts (from part one up to part five) were designed to explore, respectively:
    1. students' perspectives about the effect of the teaching methods on their achievement and problem solving skills
    2. students' perspectives towards teaching strategies
    3. students' attitudes towards mathematics
    4. expected outcomes other than achievement
    5. the external factors which may affect the learning and teaching process.

This part was analysed by using SPSS (Statistical Packages for Social Studies) to assess the students' responses to the questions of the questionnaires (as a dependent variable) according to the teaching method, gender and the interaction between teaching method and gender (as independent variables). Several types of tests were used. Multivariate Analysis of Variance (MANOVA) was used to assess any statistically significant differences between the students' responses in the two experimental groups and, hence, comparing means (Fitz-Gibbon and Morris, 1978a; Oqeili and El-shayeb, 1998; Robson, 2002). Frequencies and percentage for the items of the questionnaire were calculated. The reliability coefficient for the questionnaire was calculated by the '*Kronbach alpha*' method. Some of the above findings were calculated by using SPSS and others were calculated by the researcher herself. The findings of this part will be discussed in detail in chapter eight.

The qualitative part

Several instruments were used and qualitatively analysed in this part to minimise the complexity of the quantitative data and to discuss difference phenomena that could not be cleared by the quantitative part. These are the instruments used in this part.

1) Interviews were conducted with all teachers involved in the experiment and with a random sample of the students in the two experimental groups (A) and (B).

2) Field notes and observations were recorded by the researcher herself during the class visits of the fieldwork to evaluate to what extent teachers who were trained in how to apply cooperative learning implemented the new teaching method effectively, to assess students' interaction and cooperation within their groups and to evaluate general teaching skills in both experimental groups and how well teachers in the two experimental groups (the traditional and cooperative methods) applied their teaching methods and skills.
3) Weekly diaries were recorded by the teachers themselves to assess their judgement about the students' progress within the experiment.

7.2 Sample of the study

The quantitative part

The educational system in Jordan divides the twelve educational stages into two sub-stages: the primary stage (from the first grade up to the tenth one) and the secondary stage (the last two grades, eleventh and twelfth grade), as was mentioned in chapter two. This study concentrated on students in the upper primary basic stage and, hence, the sample of the study was chosen to be from the eighth grade because it is considered one of the most sensitive grades. It is in the middle of the upper primary stages and considered as a transitional point in which students in this stage expected to study more difficult new mathematics materials and subjects.

The study sample composed of 348 eighth grade students (approximately 14 years old). Students were from two governmental schools (female and male schools). The schools were chosen in Amman (the capital of Jordan) during the second semester of the scholastic year 2000 / 2001 and the first semester of the scholastic year 2001 / 2002. The schools were representative of schools throughout Jordan which have the same characteristics and facilities. The eight classes involved in the experiment were selected randomly and distributed to form the two experimental groups of the experiment. Four classes were from the female school (176 female students) and four classes were from the male school (172male students), thus there were eight classes in the study. Those students were taught the content of the Jordanian mathematics curriculum by eight teachers. Four teachers used cooperative learning, two of them in each of the different schools (female and male) and the other four teachers using the usual traditional methods, also two of them in each of the different female and male schools. All teachers involved in the experiment were carefully chosen and selected according to their qualifications and number of years of experiences, as will be discussed in detail in this chapter.

From each school two classes were taught using cooperative learning, those formed the experimental group (A) and the other two classes from the two schools were taught using traditional teaching methods. Those formed the experimental group (B). The sample of the study in the experimental group (A) was composed of 173 students (86 female and 87 male) and 175 students were from the experimental group (B) (90 female and 85 male). All eight classes undertook pre-tests at the beginning of the first semester and before starting the experiment. This study sample provided a cross-section of students in Jordan. A general policy in schools in Jordan is to classify the students in their classes according to their academic ability. Hence, classes were mixed ability classes and each class would have high, middle and low achieving students. Table 7.1 summarises the study sample in the quantitative part.

Table 7.1: Students Distributed Within the Experiment

Method of teaching	Gender		Total
	Female	Male	
Cooperative Learning	86	87	173
Traditional methods	90	85	175
Total	176	172	348

The qualitative part

1) All eight teachers involved in this study in the two experimental groups (A) and (B) were included. Four of those who taught by using cooperative method were trained before starting the experiment in how to use cooperative learning strategies in the mathematics classroom. All eight teachers were observed during the experiment and they were interviewed at the end of the experiment.
2) Forty eight students (24 female and 24 male) from the whole sample (348 students) were interviewed at the end of the experiment drawn from the all eight classes. The researcher was anxious to ensure that the sample was representative

of the whole population in the two experimental groups. Variables considered were related either to gender or to level of ability. Six students from each female and each male class were selected based upon advice from their teachers to ensure that representation included high, intermediate and low achieving students. It is important to emphasise that the sample was chosen to contribute to the qualitative analysis where the researcher wished to explore views and beliefs about the efficacy of different teaching methods. Selected in this manner, the sample size with its 100% response rate was considered adequate for the purpose.

3) Two head teachers from the two selected schools (female and male) participated in this study to enable the researcher to solve problems that might occur.

7.3 Variables of the Study

This study included several types of variables; some of them are independent variables, others are dependent variables and one of them was considered a covariance variable. The variables included in the pre-test and post-test assessment design were:

- the students' final achievement test after the experiment that is the post-test as a dependent variable
- the students' initial mathematical abilities before the experiment that is the pre-test as a covariance variable.

These variables were used to assess the students' progress before and after the experiment.

Other independent variables were included, such as:

- the method of teaching (cooperative and traditional)
- the gender (female and male)
- the interaction between the method of teaching and the gender.

Variables in the questionnaire were mostly the same as the variables included in the pre-test and post-test assessment design but, here there was no covariance variable, just the students' responses towards the questionnaire as a dependent variable, the method of teaching, the gender and the interaction between them as independent variables.

In brief, the dependent variables in this study were the students' final mathematical achievement, their progress within the experiment and their responses towards the method of teaching. These variables were tested quantitatively. Also, these variables were measured and analysed qualitatively throughout the research fieldwork by conducting interviews with students and teachers and observations and field notes recorded by the researcher herself and by the teachers involved in the experiment.

7.4 Time Scale of the Fieldwork

Time is the second element of the research design after the group (sample) of the study to assess who will be measured and when (Fitz-Gibbon and Morris, 1978). Many considerations were given in determining when to start, when to finish, when to apply the tests, when to conduct the interviews and why to choose these times in measuring and evaluation.

The duration of the experiment was two scholastic semesters. Within the constraints of study this period of time could not be extended, however, it is recognised that it may be a limited time to secure a real measure of the outcomes in achievement and in problem-solving skills. Figure 7.1 summarises the research method, activities and stages involved within the two semesters of the research experiment. A detailed description and discussion will be followed in next sections of this chapter.

Figure 7.1: Timetable of the Research Fieldwork

Time	Research Method	Subject involved
Sep. 2000	Preparing and organising research instruments (English language)	Pre-test, questionnaire, training syllabus, Observation sheet and weekly diary.
	Translate pre-test into Arabic language	
Jan. 2001	Translate other research instruments into Arabic language	
	Develop and pilot pre-test	5 female and 5 male students, 2 female and 2 male teachers, 3 university lectures in Hashemite University and 1 mathematics supervisor.
Feb. 2001	Jordanian schools start (second semester 2000/2001)	
	Visiting and arrangements for getting the agreement for applying the research fieldwork in Jordanian school	Ministry of Education and Educational Directorate in Amman.
	Selecting schools, teachers and students	Upper primary male school, upper primary female school, 4 female teachers and 4 male teachers and 348 female and male eighth grade students.
Mar. 2001		
	Conducting pre-test	All 348 students.
	Teachers training	2 female and 2 male teachers.
	Starting research fieldwork implementation	
	Lesson observations	Approximately 3– 4 lessons in each class.
Jun. 2001	Weekly observations diaries	Approximately 7 weekly diaries.
	Jordanian final schools exams and starting summer holiday	
Aug.2001	Arranging for continue the fieldwork for the next semester	Two head-teachers.

Sep. 2001 Jordanian school start (first semester 2001/ 2002)

Continue implementing the fieldwork for the second semester.

Lesson observations → Approximately 5-6 lessons in each class.

Weekly observations diaries → Approximately 12-14 weekly diaries.

Piloting Questionnaire → 2 female and 2 male teachers, 2 female and 2 male students, 3 undergraduate students, 3 university lectures.

Develop and pilot the post-test → 5 female and 5 male students, 2 female and 2 male teachers, 3 university lectures in Hashimite University, and 1 mathematics supervisor.

Nov. 2001

Applying questionnaires → 347 students. (1 absent student).

Conducting the interviews → All 8 teachers, 48 female and male students.

Dec. 2001

Applying post-test → All 348 students.

Collecting the final teachers' diaries and remarks

Translating and coding of the qualitative data

Jan. 2002

Arranging and coding of quantitative data

Jordanian final schools exams and starting the half-scholastic year holiday

Feb. 2002

Initial quantitative data analysis

Initial qualitative data analysis

7.5 Research Questions

This present study was designed, implemented and evaluated in order to examine the rationality for using cooperative learning in mathematics and to determine how this strategy may be applied most effectively. It assesses the effectiveness of cooperative learning strategies in promoting problem solving skills and achievement in mathematics. Moreover, it analyses the views of teachers and students on the use of cooperative learning versus traditional ones in the teaching of mathematics. In addition, it explores the general developmental progress of those students who were exposed to cooperative learning.

To achieve the previous aims, the researcher designed questions to be answered for the quantitative part of this study. These questions seek to assess the effectiveness, or otherwise, of cooperative learning strategies versus the traditional methods in promoting problem-solving skills and achievement in mathematics, examine the rationality for using cooperative learning strategies in the mathematics classroom as a voice for the two theoretical explanation in cognitive and motivational fields and the expected outcomes in the cognitive and non-cognitive domains. Also, this part explores the effects of teaching methods on students' attitudes towards mathematics and it analyses the views of students on the use of cooperative learning in the mathematics classroom. Moreover, this part investigates the impact of other factors that may affect the learning process. As a complementary part of the quantitative one, other questions for the qualitative part were designed to explain and interpret different results and observations which would arise after collecting and analysing the quantitative and qualitative data of this study.

Questions of the Quantitative Part

- **Questions relating to the pre-test / post-test results in the two experimental cooperative and traditional groups**

1. Are there any statistically significant differences in students' final mathematical achievement test (post test)
   a) in the standard of knowledge and computation, and comprehension (first part)
   b) in the standard of application and analysis (second part)

c) in general mathematical achievement and problem solving skills (total achievement, see p. 123)

related to the effect of:

- teaching method
- gender
- interaction between teaching method and gender?

2. Are there any statistically significant differences in students' mathematical achievement before and after the experiment (pre-test / post-test)
   a) in the standard of knowledge and computation, and comprehension (first part)
   b) in the standard of application and analysis (second part)
   c) In general mathematical achievement and problem solving skills (total achievement, see p. 123)

for the all experimental groups

- cooperative female
- cooperative male
- traditional female
- traditional male?

- **Questions relating to the students' responses towards the questionnaire in the two experimental cooperative and traditional groups.**

3. Are there any statistically significant differences in students' perspectives about the effects of teaching methods on their mathematical achievement and problem solving skills

related to the effect of

- teaching method
- gender
- interaction between teaching method and gender?

4. Are there any statistically significant differences in students' perspectives towards teaching strategies and teaching skills

related to the effect of

- teaching method
- gender
- interaction between teaching method and gender?

5. Are there any statistically significant differences in students' attitudes towards mathematics

related to the effect of

- teaching method
- gender
- interaction between teaching method and gender?

6. Are there any statistically significant differences in students' outcomes other than achievement (in the non-cognitive domain)

related to the effect of

- teaching method
- gender
- interaction between teaching method and gender?

7. Are there any statistically significant differences in other external factors that may affect the learning and teaching process

related to the effect of

- teaching method
- gender
- interaction between teaching method and gender?

Questions of the Qualitative Part

1) Interviews with students

These questions search for:

- **Students' attitude towards mathematics**
  - Are you interested in mathematics lessons and look forward to them? Is this a new feeling? Why?

- Do you like mathematics? Why?
- Does the teaching method highlight the importance of mathematics and its effect on your thinking in solving problems in different, new, daily life situations? If yes, how? If no, why?

- **Students' views about the method of teaching and the rationality for using it**
  - Are you satisfied and comfortable with the teaching method for mathematics? Why?
  - Would you prefer to continue using this method or return to the previous method / change the method of teaching?

- **Students' views about their performance in mathematics and their ability in problem-solving skills**
  - Does the teaching method increase the cognitive and the competitive atmosphere? If yes, how? If no, why?
  - Do you think that your achievement is getting better? Why?
  - Have you noticed that the teaching method affects your ability in solving problems? If yes, how? If no, why?

- **Assessment of students' views about teachers' ability to use the teaching method**
  - Do you think that your teacher applies mathematics teaching in a good way?
  - Should your teacher continue using the teaching method or return back to the previous method / apply a new method of teaching?

- **Other non-academic achievements of the teaching method**
  - Does the teaching method affect other non-academic achievement, for example, the relationship between you and your classmates, your personality and so on…?

- **Advantages and disadvantages of the teaching method**
  - What are the advantages and disadvantages of this teaching method?

2) Interviews with Teachers

These questions search for:

- **Teachers' views about the effects of teaching methods and strategies on the learning process**
  - How important do you think it is that the teaching method you adopt has a real effect on learning if it is used in a correct way?

- **General teaching strategies used in teaching mathematics**
  - What are the teaching strategies you use in teaching mathematics?

- **Teachers' views about the rationality to use the teaching method**
  - Do you consider the teaching method you applied as a rational strategy in teaching mathematics? Why?

- **Teachers' views about students' performance in mathematics and their ability in solving problems**
  - Have you noticed that the teaching method affects the students' performance? If yes, how? If no, why?
  - Do you think that the method of teaching enhances problem solving skills in mathematics for the students? If yes, how? If no, why?
  - Can you describe the atmosphere you feel in your class during teaching and learning? Do you think that this atmosphere progresses the learning process in mathematics?
  - Does the teaching method offer students who have a disability or who are low achieving a chance to help them to succeed?
  - Do you notice that the students' progress and improvement depend on their achievement? Alternatively, does the method affect differently according to their levels and ability?

- **Teachers' views about the training programme**
  - How confident are you of your understanding you feel as a teacher to use cooperative learning effectively as a teaching method?

- Are you satisfied about the training programme you had in how to use cooperative learning in the mathematics classroom? What are the advantages and disadvantages of this training programme?
- Would you prefer to take extra training courses in teaching strategies in mathematics? Why?

- **Teachers' attitudes toward teaching method**
  - How positively is learning improved by using cooperative learning?
  - Would you like to continue teaching by using the teaching method in the experiment in all stages you teach? Why?
  - How do you feel towards this teaching method of instruction in mathematics?

- **Teachers' views about their students' activity and other non-academic achievement**
  - Did you observe any changes in the students' activities, relations, personalities, attitudes towards mathematics and their social skills? If yes, is this new behaviour? Can you explain the reasons? If no, can you explain the reasons?

- **The teachers' views of the students' assessment of teaching method**
  - Have you heard or noticed that the students agree or disagree to apply the new/usual teaching method?

- **Teachers' views about the Jordanian mathematics curriculum in applying the teaching method**
  - Do you think that our curriculum is prepared in a good way such that you can apply any teaching method for this curriculum? If yes, why? If no, what are your suggestions?

- **The advantages and disadvantages of the teaching method**
  - What are the advantages and disadvantages of the teaching method you apply?

3) Researcher's lesson observations and field notes

Lesson observations concentrated on answering the following questions that were raised in the guidance observation sheet organised for the need of the study (appendix four).

The following questions are to be answered.

1. How did teachers in the cooperative learning group apply the new procedures and strategies in their classes relating to the training programme that had been applied before starting the experiment?
2. How did students work within their groups?
3. How did teachers use their traditional teaching skills?
4. How did students participate within their traditional classes as a whole class?

In general, to what extent does the experiment apply and what are the general teaching and learning skills in the two experimental groups including: introduction, reflection, evaluation and processing, group management, instruments and materials, students' group work and classroom management?

The guidance observation sheet was translated into the Arabic language for the purpose of research fieldwork.

4) Teachers' weekly observations diaries and their judgement about the progress of the students' skills and ability

The questions to be answered are:

1. What are the teachers' judgements about the progress of the students' skills and ability?
2. How and why might the teaching method affect such progress?

To answer the previous questions teachers will report their judgement about the following issues:

1. achieving the objectives of the lessons and mastering the mathematical assignments
2. the discussion and contribution of solving problems
3. the cooperation and the interaction between students

4. problem solving skills, including:
- understanding the mathematical concepts and rules
- the ability to use the concepts and rules in solving problems
- problem solving and its applications
- using new mathematical symbols and vocabulary
- the ability in mathematical proofs
- links between mathematical subjects
5. the interest and suspense for working
6. the students' activity
7. the competition atmosphere
8. the social relationship
9. students' attitudes towards mathematics.

In order to help teachers to report their comments the researcher summarised the previous points and re-organised guidance weekly diaries (appendix five). The organised weekly diary was designed in Arabic to meet the need of the fieldwork.

7.6 Hypotheses of the Study

Hypotheses are statements that are to be tested. The researcher tested (accepted or rejected) the null hypotheses and the corresponding alternative hypotheses for the quantitative part (pre-test / post-test design, questionnaire) according to the findings of this present study. Hypotheses related to the pre-test / post-test design were designed to examine the effects of teaching method (cooperative versus traditional), the effect of gender and the effects of the interaction between teaching methods and gender on students' mathematical achievement and problem solving skills. So, the questions of the tests concentrated on the objective and behaviour categories in the cognitive domain (knowledge, understanding, application and analysis).

Hypotheses related to the questionnaire were designed to examine the effects of teaching methods, gender and the interaction between teaching methods and gender on:

- students' perspectives towards the effect of the teaching method on their mathematical achievement and problem solving skills
- students' perspectives towards teaching strategies

- students' attitudes towards mathematics
- students' outcomes other than achievement.

Moreover, to search for the external factors that might affect the learning and teaching process in the two experimental groups.

The hypotheses were mainly related to the quantitative part of this study and were tested statistically on the significant level standard ($\alpha < 0.05$).

These are the null hypotheses and the corresponding alternative hypotheses of the study.

Remark:

H0: Denotes the null hypotheses

H1: Denotes alternative hypotheses

H2: Denotes alternative hypotheses

a) **Hypotheses related to the pre-test / post-test design**

1. Hypotheses one
   - 1. H0: Teaching methods have no affect on enhancing students' progress in mathematical achievement in the standard of knowledge and comprehension.
   - 1. H1: Cooperative learning positively enhances students' progress in mathematical achievement in the standard of knowledge and comprehension.
   - 1. H2: Traditional teaching methods negatively affect students' progress in mathematical achievement in the standard of knowledge and comprehension.

2. Hypotheses two
   - 2. H0: Teaching methods have no affect on enhancing students' progress in mathematical achievement in the standard of application and analysis.
   - 2. H1: Cooperative learning positively enhances students' progress in mathematical achievement in the standard of application and analysis.

- 2. H2: Traditional teaching methods negatively affect students' progress in mathematical achievement in the standard of application and analysis.

3. Hypotheses three

- 3. H0: Teaching methods have no affect on enhancing students' progress in mathematical general achievement and problem solving skills.
- 3. H1: Cooperative learning positively enhances the students' progress in the mathematical general achievement and problem solving skills.
- 3. H2: Traditional teaching methods negatively affect students' progress in mathematical achievement and problem solving skills.

4. Hypotheses four

- 4. H0: There are no gender differences with respect to students' final mathematical achievement in the standard of knowledge and comprehension.
- 4. H1: There are gender differences with respect to students' final mathematical achievement of the standard of knowledge and comprehension.

5. Hypotheses five

- 5. H0: There are no gender differences with respect to students' final mathematical achievement in the standard of application and analysis.
- 5. H1: There are gender differences with respect to students' final mathematical achievement in the standard of application and analysis.

6. Hypotheses six

- 6. Ho: There are no gender differences with respect to students' final mathematical general achievement and problem solving skills.
- 6. H1: There are gender differences with respect to students' final mathematical general achievement and problem solving skills.

7. Hypotheses seven

- 7. H0: Interaction between teaching method and gender has no affect on enhancing students' final mathematical knowledge and comprehension.
- 7. H1: Interaction between cooperative learning and gender positively enhances students' final mathematical knowledge and comprehension compared with the effect of the interaction between traditional teaching methods and gender.

8. Hypotheses eight
   - 8. H0: Interaction between cooperative learning and gender has no affect on enhancing students' final mathematical application and analysis compared with the effect of the interaction between traditional teaching methods and gender.
   - 8. H1: Interaction between cooperative learning and gender positively enhances students' final mathematical application and analysis compared with the effect of the interaction between traditional teaching methods and gender.

9. Hypotheses nine
   - 9. H0: Interaction between cooperative learning and gender has no affect on enhancing students' final mathematical achievement and problem solving skills compared with the effect of the interaction between traditional teaching methods and gender.
   - 9. H1: Interaction between cooperative learning and gender positively enhances students' final mathematical achievement and problem solving skills compared with the effect of the interaction between traditional teaching methods and gender.

Hypotheses related to the questionnaire

- **Hypotheses related to part one of the questionnaire**

10. Hypotheses ten
   - 10. H0: There are no differences in students' perspectives towards the effect of the teaching method on their mathematical achievement and problem solving skills.
   - 10. H1: Cooperative learning will positively enhance students' perspectives to the effect on their mathematical achievement and problem solving skills compared with traditional learning.

11. Hypotheses eleven

- 11. H0: There are no gender differences related to students' perspectives about the effect of the teaching method on their mathematical achievement and problem solving skills.
- 11. H1: There are gender differences related to students' perspectives about the effect of the teaching method on their mathematical achievement and problem solving skills.

12. Hypotheses twelve

- 12. H0: There are no differences in students' perspectives related the effect of the interaction between teaching method and gender on their mathematical achievement and problem solving skills.
- 12. H1: Interaction between cooperative learning and gender positively affects students' perspective about the effect on their mathematical achievement and problem solving skills compared with the effect of the interaction between traditional methods and gender.

- **<u>Hypotheses related to part two of the questionnaire</u>**

13. Hypotheses thirteen

- 13. H0: There are no statistically significant differences between students' perspectives and views towards teaching strategies between the cooperative and traditional groups.
- 13. H1: There are statistically significant differences between students' perspectives and views towards teaching strategies between the cooperative and traditional groups.

14. Hypotheses fourteen

- 14. H0: There are no gender differences in students' views towards teaching strategies between the cooperative and traditional groups.
- 14. H1: There are gender differences in students' views towards teaching strategies between the cooperative and traditional groups.

15.. Hypotheses fifteen

- 15. H0: Interaction between teaching method and gender has no statistically significant differences in students' views towards teaching strategies between the cooperative and traditional groups.
- 15. H1: There are statistically significant differences in students' views towards teaching strategies between the cooperative and traditional groups related to the interaction between teaching methods and gender.

- **<u>Hypotheses related to part three of the questionnaire</u>**

16. Hypotheses sixteen

- 16. H0: Teaching method has no effect on enhancing students' attitudes toward mathematics.
- 16. H1: Cooperative learning will positively enhance the students' attitudes toward mathematics compared with traditional learning.

17. Hypotheses seventeen

- 17. H0: There are no gender differences in students' attitudes towards mathematics.
- 17. H1: There are gender differences in students' attitudes towards mathematics.

18. Hypotheses eighteen

- 18. H0: There are no differences in students' attitudes towards mathematics related to the effect of the interaction between teaching methods and gender.
- 18. H1: Interaction between cooperative learning and gender will positively enhance students' attitudes towards mathematics compared with traditional learning.

- **<u>Hypotheses related to part four of the questionnaire</u>**

19. Hypotheses nineteen

- 19. H0: Teaching method has no effect on students' outcomes other than achievement.

- 19. H1: Cooperative learning will positively enhance students' outcomes other than achievement compared with traditional learning.

20. Hypotheses twenty

- 20. H0: There are no gender differences in students' outcomes other than achievement.
- 20. H1: There are gender differences in students' outcomes other than achievement.

21. Hypotheses twenty one

- 21. H0: Interaction between teaching method and gender has no effect on students' outcomes other than achievement.
- 21. H1: Interaction between cooperative learning and gender will positively enhance students' outcomes other than achievement compared with traditional learning.

- **<u>Hypotheses related to part five of the questionnaire</u>**

22. Hypotheses twenty two

- 22. H0: There are no statistically significant differences related to external factors that may affect the students' learning process between the cooperative and traditional groups.
- 22. H1: There are statistically significant differences related to external factors that may affect the students' learning process between the cooperative and traditional groups.

23. Hypotheses twenty three

- 23. H0: These are no statistically significant differences related to external factors that may affect the students' learning process between the female and male groups.
- 23. H1: These are statistically significant differences related to external factors that may affect the students' learning process between the female and male groups.

24. Hypotheses twenty four

- 24. H0: These are no statistically significant differences related to external factors that may affect the students' learning process between the female and male cooperative and traditional groups.
- 24. H1: These are statistically significant differences related to external factors that may affect the students' learning process between the female and male cooperative and traditional groups.

7.7 The Development of Research Instruments

The present study was designed to examine the rationality for using cooperative learning in mathematics and to determine how it may be applied most effectively. Also, the present study assesses the effectiveness or otherwise of cooperative learning strategies on promoting problem solving skills and achievement in mathematics. Moreover, it analyses the views of teachers and students on the use of cooperative learning versus the traditional ones in the teaching of mathematics. Finally, it explores the general progress of students exposed to the two experimental groups.

In order to achieve the aims and objectives of the study, to answer the research questions that are discussed in detail in section 7.5, to accept or reject the null and the alternative hypotheses and to evaluate the experimental programme carried out, several research instruments were designed, developed, implemented and analysed by the researcher.

The instruments used to collect research data for the qualitative part were interviews conducted with teachers and students, observations and field notes reported by the researcher herself by using lessons observation sheets and weekly diary comments reported by the teachers during the experiment. The instruments used in the quantitative part were the pre-test and post-test assessment and the programme evaluation questionnaire. These instruments were designed for several aims and objectives and were analysed quantitatively by using different statistical techniques, such as paired sample t-test, analysis of covariance and analysis of variance. Moreover, a syllabus for training teachers in how to use cooperative learning strategies in the mathematics classroom was prepared and translated into the Arabic language by the researcher for use in the teachers' training programme (see appendix seven). A detailed description for these instruments is presented in the next paragraph.

Research Instruments for the Quantitative Part

1) The pre-test and post-test assessment design

The pre-test and the post-test were used in this study to assess the progress and improvement, or otherwise, of students in mathematical achievement and mathematical problem-solving skills before and after the experiment in the cooperative and traditional groups. Both the pre-test and the post-test were designed and developed (according to that has been discussed in the previous chapter, achievement tests, pp. 110-111) to measure the following criteria

A) comprehension

B) application and problem solving.

The activities to be tested were determined on the basis of Bloom's classification of objective and behavioural categories in the cognitive domain (see page111) and the definition adopted of the problem-solving (see page 38).

The activities tested were:

A) knowledge and computations with 20 %

B) comprehension with 30 %

C) application with 30 %

D) analysis with 20 %

As part of the pilot stage, the research refined these activities (see appendix one (a), pp.354-355). This ensured that the questions accurately assessed student development in the measurement criteria adopted. In the case of general achievement, but more particularly in problem-solving which requires ability in several skills it was necessary within the marking scheme of the tests to measure student understanding through stages of working as well as at the global level which was demonstrated by solving the problem (see appendix one (c) and appendix two (c), marking schemes).

The types of the questions in the two tests were multiple-choice and open-ended. Since the sample of the study consists of 348 students from eighth grade in the upper basic primary stage in Jordan, the contents of the pre-test and the post-test were related to the contents of the Jordanian mathematics curriculum. The pre-test was applied at the beginning of the experiment in the second semester for the scholastic year 2000/2001. The contents of the pre-test covered the material that studied in the eighth grade mathematics curriculum in the first semester. The contents included five units: the real numbers, the monetary and commercial handling usage, the triangle, the factorising and the solid figures (Ministry of Education – Jordan, 1994). The first stage of developing the pre-test was to determine the objectives of each unit, to classify the content (according to the mathematical construction that has been discussed previously in chapter three) into concepts, rules and generalisations, algorithms and skills and, finally, problem solving. The second stage was to begin to put the content / process matrix to focus attention on how may items and, therefore, how much weight, should be assigned to each sub-area in the exam.

According to Bloom's classification (1956) in Morris and Fitz-Gibbon (1978a) for the objectives and behaviour categories in the cognitive domain are knowledge, comprehension, application, analysis, synthesis and evaluation. Actually, the researcher used only the first four standards as they were classified by the Evaluation Committee for the Students' Achievement in the Secondary Stage in the U.S.A. (1966) in (Abu-Zena, 1997) when they put a form to classify the behaviour objectives in mathematics into computation, comprehension, application and analysis. Also, Johnson (1985) in his study to assess the effects of the group of four cooperative learning models on students' problem-solving achievement in mathematics he used pre-test and post-test Romberg and Wearne problem-solving test. The activities tested included comprehension, application and problem solving. Table 7.2 explains the distribution of the marks for the pre-test within the contents of the units and regarding the objectives and behaviour categories in the cognitive domain. The total mark is equal to fifty. The distribution of the marks depends on the time spent in covering the contents of the units during the scholastic semester.

Within this stage a first draft for the questions of the pre-test was prepared and a final first draft of the pre-test was designed according to the content / process matrix (table 7.2). The questions in the pre- test consist of 10 multiple choice questions and five open-ended questions with their sub-questions. A final form was prepared when the pre-test had been piloted (appendix one, a).

Piloting the pre-test takes place before applying the exam at the beginning of the experiment. Forms of the pre-test with the pilot forms (appendix one, b) and a letter for the head teacher in 2 female and male schools were sent by post to Jordan to be completed by 5 female and 5 male students and to collect 2 female and 2 male teachers' comments relating to:

a) the relevance of each question to the objectives and behaviour categories in the cognitive domain (knowledge and computations, understanding and comprehension, application, and analysis)
b) the Arabic language version
c) any other changes by deletion, addition, or any other remarks.

Table 7.2
The content / objectives and behaviour categories in the cognitive domain matrix for a pre– test in mathematics.

Contents	The objectives and behaviour categories in the cognitive domain				Total
	Knowledge and Calculations	Understanding and Comprehension	Application	Analysis	
The real Numbers	Q2- (1) – 3M.	Q(1)-(1)-1M Q2- (2) – 3M. Q2- (3) – 3M.		Q1 - (10) -1M.	11
The Monetary And Commercial handling usage	Q3- (2- a) –2M.		Q3- (1) – 3M. Q3- (2- b) – 3M.		8
The triangle		Q1- (2) – 1M. Q1- (3) – 1M. Q4- (1) – 3M.	Q4- (2) – 3M.	Q4- (3) – 3M.	11
The Analysis to Factors	Q1- (4)- 1M Q1- (5) – 1M. Q1- (6) – 1M.	Q5- (1) – 2M.	Q5- (2- a) – 3M.	Q5- (2- b)-3M.	11
The solid Figures	Q1- (7) – 1M. Q1- (8) – 1M.	Q1- (9) – 1M.	Q5- (3- a) – 3M.	Q5- (3–b) -3M.	9
Total	10	15	15	10	50

The pilot forms included data about teachers' academic qualifications and numbers of years of experience. Pilot forms were distributed to 1 supervisor in mathematics and 3 university lecturers in Hashemite University who have Ph.D degrees and a professor in mathematics education. All forms were completed, collected and returned to the researcher by post to the U.K.

After collecting the data for piloting the pre-test the researcher made some changes according to the collected comments. The changes included:

a) some Arabic language changes
b) more attention to the accuracy in drawing some figures and putting some information and symbols on it
c) changing items in (Q1 (1), Q1(4) and Q3(2-b) to relate to the previous categories.

The students' answers to the piloting forms were acceptable. Any explanations were asked by students were changed and explained. The questions were acceptable to all students since they are from the same material they studied in the Jordanian mathematics curriculum.

Some teachers commented that it is quite difficult to give 30% and 20% to the questions in the application and analysis standard, but the researcher kept the same percentage for the purpose of the study was to assess the students' progress in the problem-solving skills. Moreover, advice on this issue was taken from a supervisor who is a professor in mathematics education in Hashimite University with twenty-five years of experience in that field who supported the researcher's ideas. Actually, the researcher believes that these percentages are suitable and sufficient to measure the students' problem solving skills for the quantitative part that describes students' general mathematical achievement in different standards, whereas, the qualitative part is a complementary one that explains how and why the teaching method may affect students' mathematical achievement and problem solving skills.

The previous procedures, including:

- analysing the objectives of the units for the pre-test,
- forming the content / process matrix,
- piloting the pre-test

were made in order to measure and satisfy the validity of the exam.

To measure the reliability of the pre-test the researcher found the reliability coefficient for the whole sample of the pre-test students' answers. The reliability coefficient was calculated by using SPSS (Statistical Packages for Social Studies) and by using the '*Kronbach alpha*' method. This method was used because it is suitable for any kind of question, either objective or open ended (Oqeili and El-shayeb, 1998). The reliability coefficient was found to be is equal to 0.7388. Since this value lies between 0.9- 0.68 means it is reasonable (Oqeili and El-Shayeb, 1998; Passing, 2002). Hence, it is enough and satisfactory for the purpose of the study.
The contents of the post-test, which covered the material that had been taught in the first semester for the scholastic year 2001 / 2002 in the ninth grade mathematics curriculum, included four units: the analytical geometry, factorising, the circle and the inequalities (Ministry of Education – Jordan, 1996). The same procedures used to design and develop the pre-test were used to design and develop the post-test including:

a) analysing the objectives of the contents of the units in the first semester of the ninth stage mathematics educational curriculum
b) designing the content / process matrix (table 7.3)
c) piloting the post-test, where the piloting in this stage occurred during the research fieldwork in Jordan; there were no negative comments about the exam (appendix two, b)
d) preparing the final form of the post-test (appendix two, a) that is composed of 12 multiple-choice items and other four open ended questions with their sub-questions.

All the previous steps were taken to measure the validity of the exam. In order to measure the reliability of the exam, the researcher calculated the reliability coefficient for the whole sample of the post-test. The same method used for the post-test as the pre-test was the '*Kronbach alpha*' method by using SPSS and it was equal to 0.7810 which is sufficient and satisfactory for the purpose of the study.

All the forms used in this part were translated into the Arabic language for the purpose of the study.

Table 7.3
The content / objectives and behaviour categories in the cognitive domain matrix for the post- test in mathematics

Contents	**The objectives and behaviour categories in the cognitive field**				Total
	Knowledge And Calculations	Understanding And Comprehension	Application	Analysis	
Analytical geometry	Q1-(1)-2M Q1-(2)-2M	Q1-(3)-2M Q2-(a-1)-1M	Q2-(a-2)-2M Q2-(a-3)-1M	Q2-(b)-3M	13
Factorising	Q1-(4)-2M	Q1-(5)-2M Q1-(6)-2M Q1-(7)-2M	Q3-(a)-4M	Q3-(b)-3M	15
The circle	Q1-(8)-2M	Q1-(9)-2M Q1-(10)-2M	Q4-(a)-4M	Q4-(b)-2M	12
The inequalities	Q1-(11)-2M	Q1-(12)-2M	Q5-(a)-4M	Q5-(b)-2M	10
Total	10	15	15	10	50

2) A Programme Evaluation Questionnaire

Several objectives were tested and analysed in the questionnaire (appendix three) to explore the effect of different teaching methods (cooperative learning versus the traditional one) in mathematics in different fields. The researcher designed and developed the questionnaire (according to that has been discussed in the previous chapter, questionnaire, pp. 111-113) by herself for the purpose of the study. The questionnaire consists of five separate parts. Each part has its aims and objectives to be measured. Each part of the questionnaire is described in the following sections.

Part One: Students' perspectives about the effect of teaching method on their achievement and problem-solving skills

The objectives of this part are to assess students' beliefs about the effects of teaching methods (cooperative versus traditional) on their achievement and problem solving skills (appendix three, part one). This part consists of 20 items to examine the views of students about the effect of teaching methods on:

- developing mathematical knowledge
- recalling mathematical information
- understanding mathematical concepts, rules, strategies, algorithms

- using mathematical concepts, rules, strategies and algorithms in problem solving
- using new mathematical vocabulary
- estimating the solutions
- solving word problems
- linking mathematical subject and different life situation
- promoting students' skills in solving problems.

Some ideas in this part were taken from Rivera's article (1996) that gave examples of questions that may be asked for evaluating mathematical abilities in cooperative learning groups with respect to language and vocabulary, rules, strategies, algorithms and problem solving. Some other ideas were taken from Abu-Zena (1997) who discussed some of the students' skills that highlight their ability in solving problems.

Part Two: Students' perspectives towards teaching strategies

The second part of the questionnaire was designed to assess students' perspectives towards teaching strategies used in the mathematics classroom in the two experimental cooperative and the traditional methods (appendix three, part two). This part consists of 10 items that were designed by the researcher herself.

Part Three: Students' attitudes towards mathematics

The third part of the questionnaire is an important one designed to assess the effects of teaching methods (cooperative versus the traditional ones) on students' attitudes towards mathematics.

Measuring attitudes is not a simple task since the objective has to do with affect, feelings, values or beliefs and some of these attitudes may change from time to time (Henerson, Morrison and Fitz-Gibbon, 1978). However, measuring attitudes is an important issue in the present study. This part consists of 20 items (appendix three, part three). The items were designed by the researcher herself but some ideas were taken from Abu-Zena (1998) who prepared a special questionnaire form for measuring attitudes towards mathematics.

Part Four: Outcomes other than achievement

The fourth part of the questionnaire attempts to extract expected outcomes other than achievement that may or may not be attained by using cooperative learning versus the traditional one (appendix three, part four). This part consists of 25 items that were designed also by the researcher herself. The ideas were generated from Slavin (1990a) when he discussed several outcomes of cooperative learning in the non-cognitive domain, as was discussed in detail in chapter four. The following classification explains the expected outcomes related to the items of this part.

1. Inter-group relationships (items:1, 2, 3 and 4).
2. Acceptance of academically handicapped students (items 5, 6, 7, 8, 9 and 10).
3. Self esteem (items 11, 12, 13 and 14).
4. Peer academic support (items 15, 16 and 17).
5. Internal locus of control (items 18 and 19).
6. Time on task (item 20).
7. Liking of school, class and classmates (items 21, 22, 23, 24 and 25).

Part Five: The external factors which may affect the learning and teaching process

The last part of the questionnaire was designed for the purpose of searching for other external factors that may play a role and affect the learning process. This part consists of 10 items (appendix three, part five).

During the design of the questionnaire the researcher took care to design the items to be as short, clear and easily understood as possible and to be introduced in an interesting and exciting way. Also, it was very important to put variant types of positive and negative items to remove any set response. After designing the first draft of the questionnaire, advice was provided by the Director of Studies. Then, an Arabic translation of the form for the questionnaire was prepared. Also, an Arabic pilot form for the questionnaire was prepared for the purpose of piloting the questionnaire relating to:

1. designing items for each part of the questionnaire to achieve its objectives

2. the Arabic language version
3. any other changes by deletion or addition or any other remarks.

At this stage the researcher distributed several forms of the questionnaire with piloting Arabic forms to 2 female and 2 male teachers who were not involved in the experiment, 2 female and 2 male students outside the experimental sample of this study and 3 students in the first undergraduate year in the School of Education, also, 2 university lecturers that have Ph. D degrees and one professor in mathematics education. The findings of the pilot indicated that the items are clear, understandable and relate to their corresponding parts. Some changes occurred regarding some items that have the same meaning or ideas and have been written more than once.

For measuring the reliability of the questionnaire the researcher also used the '*Kronbach alpha*' method and measured the reliability coefficient for all the sample of the questionnaires. The reliability coefficient for the whole questionnaire was 0.9229 which is high and more than satisfactory for the purpose of the study (Oqeili and El-Shayeb, 1998; Passing, 2002).

Research instruments for the qualitative part

The instruments discussed previously had been designed for the purpose of the quantitative part of this study, while other instruments were designed for the purpose of the qualitative part as a complementary part of the quantitative one. Several instruments were used for collecting data in this part.

- **Interviews with students**

  These interviews were face-to-face meetings conducted in order to obtain information and to collect data (appendix six, a) related to

  1. students' attitude towards mathematics
  2. students' views about the methods of teaching and the rationality to use them
  3. students' views about their performance in mathematics and their ability in problem-solving skills
  4. assessment of students' views about teachers' ability to use the teaching methods

5. other non-academic achievement in teaching methods
6. advantages and disadvantages of teaching methods.

The questions in the interviews were mentioned in detail in section five of this chapter (pp. 133-134).

- **Interviews with teachers**

  All teachers involved in the experiment had been interviewed (appendix six, b). The objectives of the questions of the interviews were to assess:

  1. teachers' views about the effects of teaching methods and strategies in the learning process
  2. general teaching strategies used in teaching mathematics
  3. teachers' views about the rationality for using the teaching method
  4. teachers' views about students' performance in mathematics and their ability in solving problems
  5. teachers' views about the training programme
  6. teachers' attitudes towards the teaching methods
  7. teachers' views about their students' activity and other non-academic achievement
  8. teachers' views of the students' assessment of teaching methods
  9. teachers' views about the Jordanian mathematics curriculum in applying the teaching methods
  10. the advantages and disadvantages of the teaching methods.

The questions in the interviews were also mentioned in detail in section five of this chapter (pp. 135-136).

- **Observations and field notes including the following**

1. **Lesson observation** was conducted by the researcher herself to evaluate:

- to what extent the experiment was implemented as expected
- to what extent teachers in the cooperative learning group applied the new procedures and strategies in their classes relating to the training programme that had been undertaken before starting the experiment
- how teachers were using the traditional teaching skills.

Since one important factor that plays a major role in the teaching and learning process is the teachers' skills and the teachers' characteristics, those observations were vital in order to evaluate the general teaching and learning skills in the two experimental groups.

For the purpose of this part, and to facilitate the researcher in recording the observation comments, a guidance observation sheet was designed (appendix four) and a form was translated into Arabic for use during the research fieldwork. The points observed and recorded in each observation lesson were to assess teachers' general mathematics teaching skills and included the following items:

1. introducing the lesson
2. exploration and group working
3. reflection, evaluation and processing
4. group management
5. instruments and materials
6. students' group work
7. classroom management

It is obvious that the parts related to exploration and group working, group management and students' group work were observed and recorded in the cooperative classes while the other parts of the guidance observation sheet were observed and recorded in the two experimental cooperative and traditional classes.

2. **Weekly diaries** of observations for students were reported by the teachers themselves during the experiment to focus the attention of teachers on the behaviour and the attitudes of students in their classes (both experimental groups) and to arouse teachers' judgement about the progress of the students' skills and ability during the experiment. A sample of the format of the weekly diary sheet is presented in appendix five.

For the purpose of the study a guidance weekly diary sheet was prepared in Arabic to facilitate the work of the teacher in writing up these diaries. The guidance observation sheet and the organisation of the weekly diary were designed by the researcher herself relating to the contents of chapter five which discusses in detail how to use cooperative learning in the mathematics classroom and discusses all teachers' roles and decisions and how to teach cooperative problem solving lessons for an effective implementation.

3. **A syllabus for training teachers in how to use cooperative learning strategies in the mathematics classroom**

One important instrument that had been designed and developed for the purpose of the teachers' training programme was a syllabus in how to use cooperative learning strategies in the mathematics classroom. The contents of this syllabus were the same as the contents of the sections of chapter five. An Arabic version of the syllabus was translated by the researcher herself for the purpose of the study. For piloting the syllabus, the validity of the Arabic version was tested by expert judges, such as one mathematical supervisor and one Arabic language specialist who found that the content of the syllabus were correct regarding Arabic grammar rules, dictation and expressions.

This syllabus was used during the training programme to support the teachers with basic framework and to answer the following questions.

1. What is cooperative learning?
2. What makes cooperative learning work in the mathematics classroom?
3. What are the principal components in cooperative learning?
4. When should cooperative learning be used in the mathematics classroom?
5. What are the teacher's roles?
6. What are the teacher's decisions?
7. How should the implementation of cooperative learning be started?
8. How should a cooperative learning problem-solving lesson be taught?
9. How should a mathematical lesson be adapted for use by a cooperative learning group?

7.8 Procedure of the Study

- **Deciding the starting time and the duration of the experiment**

The fieldwork for this experimental research study took place during two scholastic semesters starting in the second semester for the scholastic year 2000/ 2001 and continued after the summer holiday in the first scholastic semester for the scholastic year 2001/ 2002. Hence, the experiment was started where students were in the eighth grade (at the upper basic primary stage) and continued in the following semester where students were in the ninth grade. This was the most suitable time for undertaking the fieldwork within the constraints of the study as only three years were available for the whole study, a period which could not be extended. Another advantage was that students in the cooperative groups would observe and feel the real changes in the teaching method of mathematics, where their teachers spent one semester with them before starting the experiment. On the other hand, the teachers knew their students' performance in mathematics because they had taught them for one semester before starting the experiment. This allowed them to explore the students' progress within the experiment. However, the researcher could solve any problems raised within the fieldwork with the assistance of the head teachers and teachers involved in the experiment concerning the arrangements for starting the experiment.

- **Designing, developing and piloting research instruments**

Before starting the fieldwork stage the researcher designed and developed most of the research instruments that are to be used at the beginning of, and within, the experiment. The instruments were always supervised by the director of this study who gave his judgement and advice to reach the best standard to meet the objectives of the research. As discussed in the previous sections, all the instruments were translated into Arabic for the purpose of the study. These instruments included the pre-test and its piloting form, the post-test and its piloting form, the questionnaire, the interview questions for teachers and students, the guidance observation sheet, the guidance weekly diary and the syllabus for training teachers in how to use cooperative learning in the mathematics classroom.

- **Getting permission for conducting the research and selecting schools**

The first stage began when the researcher arrived in Jordan to undertake the fieldwork and get permission from the Ministry of Education and from the First Educational

Directorate in Amman to implement the study in the male and female schools in Amman and to apply the research instruments to the sample of the study. During the researcher's visits to the Ministry of Education and meetings with some supervisors and specialists to get agreement for undertaking the research, strong encouragement and appreciation was received for the research and for its objectives that will serve in achieving some of the educational aims and objectives during the improvement steps of the Jordanian Educational Developmental Conference (as discussed in detail in chapter two).

During this period of time the researcher arranged a meeting with a mathematics education supervisor in the Department of Educational Supervision. The meeting took place at the teachers' club. Discussion took place about teaching methods which used to be used in Jordan and comments were made that most teachers depended on the lecturing method and the conversation and discussion method. Also mentioned was that the Ministry of Education directed teachers to use new teaching methods, such as working in groups and the investigation and the exploration methods. This study was strongly welcomed and comments were made that, usually, there were no special in-service training programmes in teaching by using cooperative learning. This method of teaching had just been discussed as one of other teaching methods during the courses of training and identified as group-work or group learning.

The arrangements for getting the agreement for undertaking the research took a period of time. Within this time the researcher visited different male and female schools and met the head teachers of these schools to select schools for undertaking the research relating to the number of classes in the eighth grade, number of mathematics teachers available, their qualifications and their number of years of their experience. Fortunately, there were some big schools in Amman with quite large numbers of teachers. The researcher chose one female and one male school. Each school had 8 eight-grade classes with different mathematics teachers. The head teachers and the teachers of those schools welcomed the researcher to undertake the research at their schools. However, schools were selected to represent schools in Jordan. No attempt has been made in the study to select special circumstances or conditions in Jordan but rather typical educational environments have been used with all the normal strengths and weaknesses.

The previous steps in the fieldwork occurred at the beginning of the second semester (February/ 2001) but the real implementation did not take place until the researcher received the copy of the agreement from the Educational Directorate in Amman in March/ 2001. The head teachers of the experimental schools offered help and assistance to the researcher to save time and to make some arrangements for applying the experiment. During this period of time the researcher translated the syllabus for training teachers in how to use cooperative learning in the mathematics classroom while other instruments (pre-test, post-test, questionnaire, interviews, observations, diaries) had been translated and prepared previously.

- **Applying the teacher training programme and conducting the pre-test**

The second stage was to undertake the training programme with the selected cooperative teachers. All teachers agreed to and welcomed using cooperative learning strategies in their mathematics lessons because this experiment will develop their teaching skills and will support them in their career position. Therefore, and to avoid any impact related to teachers' enthusiasm, teachers who used cooperative learning had been chosen randomly.

Four classes were selected randomly from each male and female schools such that classes were taken by different teachers. Two teachers in each male and female schools from the classes were selected to be trained and to use cooperative learning in teaching mathematics for that semester and to continue using cooperative learning for another semester at the first semester of the ninth grade with the same sample of students. The other two teachers in each school did not take any training programme and were asked to teach their classes as they usually do. Moreover, they were asked not to use cooperative learning strategies in their classes during the period of the experiment. A meeting took place at the beginning of the experiment with the teachers in each school who taught by using the traditional teaching methods for the following reasons.

1. Identifying the aims and the objectives of the study.
2. Arranging with teachers for the purpose of the researcher's classroom visits and any meeting might occur.

3. Asking teachers to give regular weekly quizzes to the students in their experimental classes.
4. Giving teachers a copy of the weekly diary to be completed by the teachers themselves to assess their judgement about the progress of the students' mathematical skills and ability.
5. Arranging for applying the pre-test and giving copies of the exam and the prepared answer key to be conducted before starting the experiment for all classes involved in the experiment at the same time.

These meetings occurred within the period of the training programme and before giving the green light to start the experiment. On the other hand, some arrangements had been made with the assistance of the head teachers and other teachers to arrange for a suitable time for the training programme. The duration of the training programme was approximately three weeks within the period extended from 18/ 3/ 2001 – 4/ 4/ 2001. On Thursday the 5 April 2001 all experimental groups in the two cooperative and traditional classes started the implementation of the experiment.

Using cooperative learning strategies in the mathematics classroom requires a different approach to planning and teaching than the traditional methods of instruction. This training programme provided teachers with the best framework to help them attain effective implementation. A detailed discussion for the training programme activities is given in appendix seven. As mentioned before, the contents of the syllabus and the headings which were addressed and discussed in the training programme were prepared regarding the efforts of the researcher and workers in the field of cooperative learning studies. Moreover, the contents related to the basic components and rules that were studied and developed by the researcher according to literature review in chapter five of this study (the use of cooperative learning in the mathematics classroom).

- **Starting implementation**

The real implementation for the experiment took place within the first semester of the experiment and covered two months only (April and May/ 2001). The contents of the Jordanian mathematics curriculum covered within this period of time included the following units (Ministry of Education – Jordan, 1994):

1. linear equations systems
2. trigonometric ratio for angles
3. probabilities.

The researcher was aware that this period of time might be a limited one in which to secure a true measure of the outcomes of achievement and problem-solving skills. So, the duration of the experiment was extended for two semesters in order to give enough time to get a real measure for the effects of applying this new method of teaching. At the beginning of June 2001 all students, teachers and employees in the Jordanian schools prepared themselves for the final exams for the second semester of the scholastic year 2000/2001 and starting the summer holiday.

During the summer holiday the researcher arranged with the head teachers of the schools to keep the students in their classes and the same mathematics teachers involved in the experiment to continue the implementation of the experiment during the first semester of the scholastic year 2001/2002. The students returned to their schools early in September 2001; they were in the ninth grade of the upper primary basic stage. The Jordanian mathematics curriculum contents covered within that semester included the following (Ministry of Education – Jordan, 1996):

1. analytical geometry
2. factorising
3. the circle
4. inequalities.

- **Observations and field notes**

During the time for implementing the experiment within the two semesters, observations were conducted and field notes were reported for the qualitative part of this study. These observations were reported firstly by the researcher herself during her class visits in the two experimental groups to assess:

1. to what extent the teachers who were trained and applied cooperative learning strategies used this method of teaching
2. the students' interaction within their groups.

Also these observations took its place in the traditional classes to:

1. assess how well the teachers are using the traditional teaching methods
2. the students' interaction as a whole class.

In general, these observations determined the general teaching skills applied within the teaching and learning process in the cooperative and traditional classrooms and the students' interaction and participation in solving the mathematical problems. Each class was observed nine to ten times during the experiment. The duration of these observations was 40-50 minutes which is approximately the same as the lesson time. After observing these lessons, continuous feedback was given to teachers who applied cooperative learning strategies to improve and develop the level of implementation and as a basic aim of this study for examining the rationality for using cooperative learning in the mathematics classroom. No such feedback was given for the observations which occurred at the end of the experiment as a general evaluation for implementation. Also, no such feedback was given to the teachers who applied the traditional teaching methods.

Another kind of observations data was collected by the teachers themselves involved in the experiment by reporting their weekly diaries to explore their judgement about the students' progress in their mathematical abilities and skills and their interaction and behaviour within the groups.

Data from all of these observations were collected for the purpose of the qualitative part and were analysed qualitatively.

- **Conducting interviews**

Other qualitative data were collected through the interviews conducted at the end of the experiment with all teachers and a random sample of students involved in the two experimental teaching methods. Forty eight students were interviewed (24 female and 24 male students), six students from each class. The samples of these students were collected randomly from each class enrolled by the researcher herself without any consideration of their level of achievement or teachers' suggestions.

The interviews took nearly three weeks in November 2001 and were audio recorded and transcribed. This technique was used to save time and to enable the researcher to transcribe accurately all comments and answers. To make the interviewees comfortable, the researcher interviewed them in their normal places. Teachers were interviewed in their rooms and students were interviewed in their own classes. The duration of the interviews conducted with teachers varied from 40 to 55 minutes, whereas the interviews with students tasted between 20 and 25 minutes. The data collected were translated from Arabic to English and were reorganised related to its objective and to the research questions to be analysed qualitatively.

- **The questionnaire**

Within the second semester the researcher prepared the post-test and piloted the test, as discussed in detail previously. The questionnaire that had been already prepared and translated into Arabic was also piloted within this semester. The drafts of these instruments were revised and the final forms were prepared and written. The researcher distributed the questionnaire by herself to the students involved in the experiment to offer them the freedom and comfort to answer the questionnaire. The researcher usually reminded students that anonymity would be considered such that the study would not identify the actual names of the students or teachers or even the schools.

It took nearly four days to complete the questionnaire and collect them back. Enough time was given to the students to complete the questionnaire; approximately an hour and a quarter to an hour and a half was spent distributing, completing and collecting the questionnaire in each class. Conducting the interviews and the questionnaires occurred at the end of the experiment (November and early December/2001) before conducting the post-test. That was to avoid any interruption or effect between the students' final achievement and their responses or teachers' responses.

- **Conducting the post-test**

The final stage of the fieldwork of this study was conducting the post-test. All teachers involved in the experiment were given forms of the post-test and it was arranged for all classes to apply the test on the same day and at the same time. An answer key was prepared by the researcher herself for marking the test (as well as the same procedures applied for the pre-test) to avoid any personal differences in evaluation. All possibilities for solving the open-ended questions were also considered. The researcher remarked a random sample of students' answers from each class to ensure that marking and scoring was done properly. The researcher collected other data, like the weekly diaries from the teachers and the students' post-test forms, to be used within the stage of the quantitative and qualitative analysis.

- **Acknowledgement**

The final visits to the cooperative schools were at the end of December 2001 while all teachers, students and schools' staff prepared themselves for the final exams for the scholastic semester for the academic year 2001/2002. The researcher visited students in their classes to thank them for their contribution and presented many thanks to the teachers involved in the experiment for their hard work during the fieldwork. Thanks and gratitude were presented to the head teachers for their contribution and offering all assistance and facilities to enable the researcher to break down any barriers that may have been faced by the researcher during the implementation. Actually, it was a wonderful example of cooperative schools creating a very warm relationship between the researcher and the participators.

- **Quantitative and qualitative data analysis**

The next stages were the quantitative and qualitative analytical stages.

Several statistical analyses with different statistical techniques were used for analysing the quantitative data in order to answer the research questions for the pre-test / post-test design (pp.131-132) and to test its hypotheses (pp.139-141). Multivariate analysis of covariance (MANCOVA) was used to assess if there were statistically significant differences in the post-test students' achievement (as a dependent variable) according to the pre-test (as a covariance variable) and related to the teaching method, gender and the interaction between teaching method and gender in the two experimental groups (as independent variables). Paired sample t-test was used to assess if there were statistically significant differences in students' mathematical achievement before and after the experiment. The progress of the students involve in the two experimental groups was evaluated by comparing means and calculating the percentage of the success and failure.

To answer the research questions related to the different parts of the questionnaire (pp.132-133) and to test its hypotheses (pp.141-145) several statistical techniques were used. Multivariate analysis of variance was used to assess if there were statistically significant differences in students' response towards the different parts of the questionnaire (as a dependent variable) and related to teaching method, gender and the interaction between teaching method and gender (as independent variables). Comparing means were used to assess the general outcomes of the questionnaire, whereas the frequencies and percentages techniques were applied to highlight the outcomes more accurately.

Students' response for the first four parts of the questionnaire were of 5- scale Likert-type and they varied from *strongly agree*, *agree*, *uncertain*, *disagree* and *strongly disagree* while students' response toward the last part was to answer questions by *yes* or *no*. Within the statistical analysis stage, 5-point scales were used to reflect the students' response for the first four parts, while 2-point scales were used for the last part. The weights of these five points for *strongly agree*, *agree*, *uncertain*, *disagree* and *strongly disagree* were 5,4,3,2 and 1, respectively and the weights of the two points were 2-points for *yes* and 1-point for *no*. With respect to the negative items the weights were in the opposite order. The recording for the negative items was done during the data entry stage and before doing the analysis.

The researcher used a 5-point Likert scale in the questionnaire to let students feel free and comfortable to represent their response. During the analytical stage, frequencies and percentages calculated for *agreement*, *uncertain* and *disagreement* where the researcher gathered between *strongly agree* and *agree* (*agreement*) and between *strongly disagree* and *disagre* (*disagreement*). This procedure was used to give more accuracy and certainty to the answers and because there may not be real differences between *strongly agree* and *agree*.

With respect to the qualitative part, the data collected were analysed qualitatively. Miles and Huberman (1994) in Robson (2002, p. 459) gave a basic set of analytical moves for the use of qualitative data analysis:

> " - Giving codes to the initial set of materials obtained from observation, interviews, documentary analysis, etc.;

- adding comments, reflections, etc. (commonly referred to as 'memos');
- going through the material trying to identify similar phrases, patterns, themes, relationships, sequences, differences between sub-groups, etc.;
- taking these patterns, themes, etc. out to the field to help focus the next wave of data collection;
- gradually elaborating a small set of generalisations that cover the consistencies you discern in the data;
- linking these generalisations to formalised body of knowledge in the form of constructs or theories."

Data collected for several research instruments (interviews, observations and diaries) had been classified according to the different issues to be analysed relating to the research aims and objectives and had been discussed under specific headings related to each issue. Students' and teachers' responses to the questions of the interviews had been classified under a list of all the topic areas covered by the data collected (pp. 133-136). Also, with respect to the observations and diaries, data collected had been organised and classified under its specific topics to be assessed (pp.137-138).

Data collected had been analysed in the following way.

1. Data collected had been transcribed on paper under its specific topics to be assessed.

<u>Remark:</u>

- Data collected within the observations and diaries had been already recorded on its special forms (see appendices four and five).
- With respect to data collected within the interview, brief notes were recorded with a reference to the interview page number to save time. A number of participants who shared the same perceptions under each topic were calculated to estimate the weight and variety of perspectives expressed.

2. Comments and general ideas were added.
3. Going through the material carefully to identify similar phrases, patterns, relationships, or differences between subgroups.
4. Step by step general generalisations had been derived.
5. Finally, forming final statement and constructs.

Then, it was explained and discussed through the analytical stages for different issues to be analysed (as will be presented in detail in the next chapter).

7.9 Final Statement

Within the contents of this chapter, the researcher displayed the methodology followed during the research study and discussed in detail: the design, the sample, the variables, the time, the questions, the null hypotheses, the instruments and the procedure of the research.

Conducting such an experimental research study requires thorough preparation in an effective way in order to enable the researcher to achieve the research objectives and to answer its questions. Therefore, there was a need to review the literature in how to design, implement and evaluate an experimental research study. However, while the contents of the previous chapter (chapter six) highlights basic issues related to the methodology of the research discussed within the contents of this chapter (chapter seven), the following chapter (chapter eight) presents in detail the quantitative and qualitative analysis with discussion to all issues to be assessed and evaluated in this present study.

Chapter Eight

Data Analysis and Discussion

Chapter Eight

Data Analysis and Discussion

8. Introduction

Once data had been collected the researcher began to organise it relating to the research aims and started to answer the questions of the study related to the quantitative and qualitative data. In this chapter the researcher analyses the quantitative data collected and the qualitative data, as well as complementary to the data which cannot be measured or tested quantitatively. For example, while findings in the quantitative part answered the questions related to students' general achievement in the exams or their response towards the questionnaire, findings in the qualitative part answered the questions how and why such outcomes arise. In addition, a discussion of a combination of the quantitative and qualitative data analysis was made to assess any interrelationships or differences which may arise for each issue that is to be measured or tested within the findings of the study.

In order to present the findings of the study in an accurate and clear way, to enable the reader easily to understand and gain the outcomes of the study, the researcher divided the contents of this chapter to demonstrate the analysis and results of the quantitative and qualitative data collected for each issue, separately, to be measured and tested in this study. One basic issue to be highlighted in this study is to assess the effectiveness, or otherwise, of using cooperative learning strategies versus the traditional one in promoting problem-solving skills and achievement in mathematics. Other, different, issues have to be assessed, such as: analysing the views of teachers and students on the use of cooperative learning versus traditional teaching methods in the teaching of mathematics; exploring empirically the effects of teaching methods on students' attitudes towards mathematics and the outcomes in the non-cognitive domain; evaluating the general developmental progress of students exposed to cooperative learning as well as the traditional classes. Another issue that has been considered within the analysis of the data collected within this study is the effects of other factors that may influence the teaching and learning process, such as students' ability, teaching skills and teachers' characteristics, gender differences, motivation, classroom management, curriculum, language, ethnicity and social classes. Actually, all these issues examine the basic issue in this research which is the rationality for using cooperative learning in the mathematics classroom.

Several research instruments were used for collecting data to achieve the research aims and to answer its questions. The following table (8.1) summarises the basic issues to be addressed in this chapter and to be analysed to answer its questions. In addition, it presents the instruments used in collecting data related to these objectives.

Table 8.1

Summary of research aims and objectives, research questions and the instrument used for collecting related data

Research aims	Research Questions	Research Instruments
Examine the rationality for using cooperative learning in the mathematics classroom.	Should we consider cooperative learning a rational strategy in mathematics teaching, and if so, why?	All research instruments used.
- Assess the effectiveness of cooperative learning versus the traditional one in promoting problem solving skills and achievement in mathematics.	- How effective is cooperative learning in promoting problem solving skills and achievement in mathematics? Why?	• Pre-test / post-test design. • Questionnaire (part one). • Interviews with teachers. • Interviews with students.
- Analyse the views of students on the use of cooperative learning and traditional ones in the teaching of mathematics.	- What are the students' views of the use of the cooperative learning and the traditional ones in the mathematics classroom? Why?	• Questionnaire (part two). • Interviews with students
- Analyse the views of teachers on the use of cooperative learning and traditional ones in the teaching of mathematics.	- What are the teachers' views of the use of cooperative learning and the traditional ones in mathematics? Why?	• Interviews with teachers.
- Assess the effects of cooperative learning versus the traditional one on students' attitude towards mathematics.	- How may cooperative learning affect on students' attitudes towards mathematics versus the traditional one?	• Questionnaire (part three). • Interviews with students. • Interviews with teachers.

Research aims	Research Questions	Research Instruments
- Explore other outcomes expected in the non-cognitive domain in cooperative learning versus traditional.	- How may cooperative learning affect students' outcomes other than achievement in the non-cognitive domain?	• Questionnaire (part four). • Interviews with teachers. • Interviews with students.
- Search and assess the impact of other factors that may affect the teaching and learning process.	- How may other factors affect students' outcomes in the two experimental groups?	• Questionnaire (part five). • Lesson observations. • Interviews with teachers. • Interviews with students.
- Evaluate the training programme and the teachers' response to it.	- How teachers can best be trained to use cooperative learning and to what extent do they apply the teaching training programme?	• Lesson observations. • Interviews with teachers.
- Evaluate the teaching skills in traditional classrooms.	- How well do the teachers in the traditional classroom apply the teaching method?	• Interviews with teachers. • Lesson observations.
- Evaluate the general developmental progress of students involved in the experiment.	- In what ways might cooperative learning contribute to the broader development of students?	• Weekly diaries.
- Develop the implementation of cooperative learning in the mathematics classroom.	- What recommendations may be advanced from this study to improve cooperative learning in mathematics?	• Research findings.

The following sections represent in detail the analytical stage of the research results.

8.1 First Issue: Assessing the effects of teaching methods (cooperative versus traditional) in promoting problem solving skills and achievement in mathematics

The quantitative part

a) The pre-test / post-test assessment

A pre-test / post-test achievement and problem solving skills assessment was used to assess the students' mathematics progress before and after the experiment. The tests measured comprehension and understanding, application and problem solving. The following activities were tested.

(a) Knowledge and computation, and comprehension: 50 % of the total mark of the exam.

(b) Application and analysis: 50 % of the total mark of the exam.

These activities relate to the objectives and behaviour categorised in the cognitive domain as discussed in detail in the previous chapter.

After collecting the results of the pre-test, it was very important to calculate the means and the standard deviation of the students' scores in the two experimental groups before the experiment. This to determine whether or not the samples of the students in the two experimental groups (cooperative versus traditional) were equivalent and to assess the initial ability of the students before starting the experiment (table 8.2).

Table 8.2
Mean and standard deviation for the pre-test students' achievement (total mark=50) in the two experimental groups

Gender		Female		Male	
Method	Standard	Mean	Std. Deviation	Mean	Std. deviation
Cooperative	PREA	9.0349	4.9216	10.4828	4.7247
	PREB	6.7442	6.1495	7.6897	6.4615
	PRET	15.5698	10.3646	18.3103	10.5250
Traditional	PREA	14.8889	5.9463	11.3176	5.8538
	PREB	10.6889	8.4237	7.3882	6.4901
	PRET	25.4667	13.3199	19.0588	10.9178

PREA: Pre-test in the standard of knowledge and computation / and comprehension (total mark =25).
PREB: Pre-test in the standard of analysis and application (total mark = 25).
PRET: Pre-test total achievement. (Total mark = 50).

Table 8.2 presents the mean and the standard deviation of the students' scores for the two experimental groups in their total mathematical achievement and in detail about their achievement in the standard of knowledge and computation, and understanding and problem solving. It is clear from the table that the sample of the study of the students in the two experimental groups (cooperative versus traditional) was not equivalent in the female cooperative and traditional groups, while there were few differences between male students in the cooperative and traditional groups. However, the two experimental groups (cooperative and traditional) were not needed to be equivalent to each other in the study since the basic aim is to assess the students' progress before and after the experiment as a correlated sample for each of the female and male groups separately. Moreover, table 8.2 indicates that all groups have a lower mean in the parts of the pre-test related to the standard of application and analysis rather than standard of knowledge and computation, and comprehension. This addresses the weakness of the students' ability in the higher standard of the mathematical thinking in application and problem-solving. Actually, this issue highlights the need for such a study and supports such research in trying to find out the effects of cooperative learning strategies in promoting problem solving skills and achievement in mathematics. With respect to the female group, one teacher commented:

> "Although students are usually distributed in their classes regarding their abilities and achievement such that the classes are mixed ability classes, one class from the traditional group contained more high achieving students that created a high level of competition between them and to form one standard class within the eight classes in the eighth grade in the school. "
>
> Female teacher, traditional group.

This explains the lesser mean for the students in the cooperative group which is not much more than the mean of the students in the male group.

The mean and standard deviation of the post-test were calculated to be compared with the pre-test. Table 8.3 represents the groups' means and standard deviation for different standards and for the whole achievement in mathematics in both the pre-test and the post-test to be compared.

Table 8.3
Mean and standard deviation for the pre-test and post-test students' achievement (total mark=50) in the two experimental groups

Gender		Female		Male	
Method	**Standard**	**Mean**	**Std. Deviation**	**Mean**	**Std. Deviation**
Cooperative	PREA	9.0349	4.9216	10.4828	4.7247
	POA	12.6163	5.5416	12.9540	5.7119
	PREB	6.7442	6.1495	7.6897	6.4615
	POB	12.7442	7.5181	9.8168	7.5321
	PRET	15.5698	10.3646	18.3103	10.5250
	POT	25.3023	12.1550	22.4483	11.4777
Traditional	PREA	14.8889	5.9463	11.3176	5.8538
	POA	15.2111	6.1324	11.1412	5.1896
	PREB	10.6889	8.4237	7.3882	6.4901
	POB	10.4444	8.9995	6.1647	5.7235
	PRET	25.4667	13.3199	19.0588	10.9178
	POT	25.5111	14.2500	17.4235	9.9850

PREA: Pre-test in the standard of knowledge and computation / and comprehension (total mark = 25).
POA: Post-test in the standard of knowledge and computation / and comprehension (total mark = 25).
PREB: Pre-test in the standard of analysis and application (total mark= 25).
POB: Post-test in the standard of analysis and application (total mark=25).
PRET: Pre-test total achievement (total mark=50).
POT: Post-test total achievement (total mark=50).

To assess if there are statistically significant differences between the two experimental groups in the effect of teaching method, gender and the interaction between teaching method and gender (as independent variables) on the students' mathematical achievement in different levels (as dependent variables) according to the pre-test (as a covariance variable). Since the sample of the students in the two experimental groups were not equivalent, multivariate (since we have many variables) analysis of covariance was used (table 8.4).

Table 8.4 indicates the statistically significant differences ($p < 0.05$) between the different variables of the study. This statistical technique was used since it is difficult for the researcher herself to calculate where there were different variables and groups within the study (Fitz-Gibbon and Morris, 1978a).

Table 8.4

Multivariate analysis of covariance of the post-test according to the pre-test, teaching method, gender and the interaction between teaching method and gender of students in the two experimental groups

Source of variance	Dep. Var.	Sum of squares	D f	Mean Square	F	Sig.
Corrected Model	POA	5706.753 a	6	951.126	54.616	.000
	POB	15025.155 b	6	2504.192	135.299	.000
	POT	36130.391 c	6	6021.732	119.565	.000
Intercept	POA	1720.862	1	1720.862	98.816	.000
	POB	367.725	1	367.725	19.868	.000
	POT	3533.538	1	3533.538	70.161	.000
PREA	POA	22.426	1	22.426	1.288	.257
	POB	48.764	1	48.764	2.635	.105
	POT	12.924	1	12.924	.257	.613
PREB	POA	19.001	1	19.001	1.091	.297
	POB	366.685	1	366.685	19.812	.000 *
	POT	191.040	1	191.040	3.793	.052
PRET	POA	112.270	1	112.270	6.447	.012
	POB	49.277	1	49.277	2.662	.104
	POT	359.140	1	359.140	7.131	.008 *
Method	POA	236.733	1	236.733	13.594	.000 *
	POB	1656.839	1	1656.839	89.517	.000 *
	POT	2991.914	1	2991.914	59.406	.000 *
Gender	POA	126.423	1	126.423	7.259	.007 *
	POB	589.254	1	589.254	31.837	.000 *
	POT	1267.472	1	1267.472	25.166	.000 *
Method * Gender	POA	20.936	1	20.936	1.202	.274
	POB	121.870	1	121.870	6.584	.011 *
	POT	80.474	1	80.474	1.598	.207
Error	POA	5921.062	340	17.415		
	POB	6292.938	340	18.509		
	POT	17123.580	340	50.363		
Total	POA	70063.000	347			
	POB	54417.000	347			
	POT	231112.000	347			
Corrected Total	POA	11627.816	346			
	POB	21318.092	346			
	POT	53253.971	346			

* Significant ($p < 0.05$)
Dep. Var.: Dependent variable.
F: F value.
d f : Degree of freedom.
PREA: Pre-test students' achievement in the standard of knowledge and computation / and comprehension.
PREB: Pre-test students' achievement in the standard of application and analysis.
PRET: Pre-test students' total achievement.
POA: Post-test students' achievement in the standard of knowledge and computation / and comprehension.
POB: Post-test students' achievement in the standard of application and analysis.
POT: Post-test students' total achievement.

Table 8.4 shows that:

1. There are no statistically significant differences in the post-test students' achievement in the standard of knowledge and computation, and comprehension (POA) related to the pre-test in the same standard (PREA).

2. There are statistically significant differences in the post-test students' achievement in the standard of application and analysis (POB) related to the pre-test in the same standard (PREB).

3. There are statistically significant differences in the post-test students' total achievement (POT) related to the pre-test in the same standard (PRET).

4. There are statistically significant differences in the post-test students' achievement in all standards (POA, POB, POT) related to the method of teaching.

5. There are statistically significant differences in the post-test students' achievement in all standard (POA, POB, POT) related to gender. That indicates that there are gender differences in students' achievement in all standards, hence:
   - Hypothesis 4. H0, 5. H0 and 6. H0 are rejected.
   - Hypothesis 4. H1, 5. H1 and 6.H1 are accepted.

   Remark: for hypothesis 4.H0, 4.H1, 5.H0, 5.H1, 6.H0 and 6.H1 see page 140.

6. These are statistically significant differences in the post-test students' achievement in the standard of application and analysis (POB) related to the interaction between teaching method and gender, hence:
   - Hypothesis 8. H0 is rejected.
   - Hypothesis 8. H1 is accepted.

   Remark: for hypothesis 8. H0 and 8.H1 see page 141.

7. There are no statistically significant differences in the post-test students' achievement in the standard of knowledge and computation, and comprehension (POA) and total achievement (POT) related to the interaction between method of teaching and gender, hence:
    - Hypothesis 7. H0 and 9. H0 are accepted.
    - Hypothesis 7. H1 and 9. H1 are rejected.

   Remark: for hypothesis 7. H0, 7. H1, 9.H0 and 9. H1 see page 141.

Since there are statistically significant differences in students' mathematical achievement in the post test (POA, POB, POT) in all standards related to method of teaching and gender (findings 4,5), comparing means according to the method of teaching and gender makes sense. Table 8.3 shows that, in all standards of the POA, POB and POT, female students in cooperative and traditional classes achieve more than the male groups except in the cooperative group where the male students achieve more than the female cooperative group in the POA with little differences. These results indicate that female students achieve more than male students, which explains the gender differences. With respect to the effect of teaching method on students' achievement in the POA, POB and POT, table 8.3 reveals that:

1. the male students in the cooperative group achieve more than the male students in the traditional group in all standards
2. the female traditional group achieves more than the female cooperative group in the POA and POT
3. the female cooperative group achieves more in the POB.

Actually, comparing means in the male group makes sense because there were few differences in their means in the pre-test while comparing means in the female group must be discussed more accurately since the female students in the two cooperative and traditional groups were not absolutely equivalent and there were clear differences in their initial abilities. So, table 8.4 indicates that there are statistically significant differences between the PREB and POB, and between the PRET and POT (findings 2, 3), while there are no statistically significant differences on the POA related to the PREA (finding 1) and, in order to assess if there are statistically significant differences in students' progress in these standards before and after the experiment and since the sample of the study in the two experimental groups were not equivalent as it clearly was previously, a paired sample t-test (Oqeili and Shayeb, 1998) was used to answer the hypothesis related to this issue (Hypotheses 1, 2, and 3). Table 8.5 summarises the findings of this test on the significant level standard ($\alpha < 0.05$). For more descriptive statistics see appendix nine (a).

Table 8.5
Paired sample t-test of the pre-test and post-test students' achievement in different standards for the two experimental groups

		Paired Differences				
Group	**Correlated pairs**	**Mean**	**Std. Deviation**	**T**	**d f**	**Sig.**
Cooperative female (N = 86)	Pair 1 PREA & POA	-3.5814	4.4204	-7.513	85	.000 *
	Pair 2 PREB & POB	-6.0000	5.7558	-9.667	85	.000 *
	Pair 3 PRET & POT	-9.7326	9.0948	-9.924	85	.000 *
Cooperative male (N = 87)	Pair 1 PREA & POA	-2.4713	4.1898	-5.502	86	.000 *
	Pair 2 PREB & POB	-2.1264	3.5790	-5.542	86	.000 *
	Pair 3 PRET & POT	-4.1379	5.4307	-7.107	86	.000 *
Traditional female (N = 90)	Pair 1 PREA & POA	- .3222	2.4851	-1.230	89	.222
	Pair 2 PREB & POB	.2444	3.1133	.745	89	.458
	Pair 3 PRET & POT	- .44E-02	2.8121	- .150	89	.881
Traditional male (N = 85)	Pair 1 PREA & POA	.1765	6.5668	.248	84	.805
	Pair 2 PREB & POB	1.2235	4.5732	2.467	84	.016 *
	Pair 3 PRET & POT	1.6353	10.0224	1.504	84	.136

* Significant ($\alpha < 0.05$).
N : number of students.
df: degree of freedom.
t: t value.

Table (8.5) reveals that:

1. There are statistically significant differences between the pre-test and post-test students' achievement in all standards before and after the experiment in the cooperative female group.
2. There are statistically significant differences between the pre-test and post-test students' achievement in all standards before and after the experiment in the cooperative male group.
3. There are no statistically significant differences between the pre-test and post-test students' achievement in all standards before and after the experiment in the traditional female group.

4. There are no statistically significant differences between the pre-test and post-test students' achievement in the standard of knowledge and computation, and comprehension in the traditional male group.
5. There are no statistically significant differences between the pre-test and post-test students' total achievement in the standard in the traditional male group.
6. There are statistically significant differences between the pre-test and post-test students' achievement in the standard of application and analysis in the traditional male group.

From these results, and from comparing means from table 8.3, it clears that:

1. Students in the female and male cooperative groups achieved more in the post-test than they achieved in the pre-test in all standards. Hence,
   - Hypothesis .1. H1, 2. H1 and 3. H1 are accepted.
   - Hypothesis 1. H0, 2 H0 and 3. H0 are rejected.

2. Students in the traditional male group achieved less in the post-test than the pre-test in the standard of application and analysis with statistically significant differences. Hence,
   - Hypothesis 2. H2 is accepted for the male group.

3. The achievement of the traditional female group in all standards and the achievement of the male group in the standard of knowledge and computation, comprehension and in the total achievement in the pre-test and in the post-test has no statistically significant differences. Hence,
   - Hypothesis 2.H2 is rejected for the female group.
   - Hypothesis 1. H2 and 3. H2 are rejected.

<u>Remark:</u> for hypothesis 1.H0, 1.H1, 1.H2, 2.H0, 2.H1, 2H2, 3.H0, 3.H1 and 3.H2 see pages 139-140.

Actually, the finding in table 8.5 support the finding in table 8.4 which is that there are statistically significant differences in achievement in the standard of application and analysis related to the interaction between teaching method and gender. These statistically significant differences arise in the traditional male group. Obviously, from table 8.3 the traditional female group achieved more than the traditional male group before and after the experiment. In addition, although the achievement of the cooperative male group was more than the achievement of the cooperative female group before the experiment, the cooperative female group achieved more than the cooperative male group after the experiment. This indicated that cooperative learning affects differently in the female and male groups and more positively towards the female group. These findings explain the gender differences and the effects of the interaction between gender and teaching method. Actually, the real differences arise from the achievement in the standard of application and analysis.

All previous findings highlight the positive effect of cooperative learning strategies in promoting mathematical achievement, especially at the level of application and problem solving skills. Moreover, cooperative learning affects the female group more positively than the male group. Traditional teaching methods have no real effects on the students' achievement in all standards except application and analysis that affects negatively in the traditional male group.

To give more discussion and explanation about the progress of the students within the experiment, the frequencies and the percentage of the success and failure of the students were calculated. Table 8.6 represents these frequencies and percentages.

Table 8.6
Frequencies and percentage for the success and failure in the two experimental groups for the pre-test and the post-test in the total achievement
(Success score 50 % - 25/50)

Method	Gender	Test	Frq. S.	Frq. F.	Frq. T	Per. S	Per. F	Per. T
Cooperative	Female	PRE	15	71	86	17.44 %	82.56 %	100 %
		POST	45	41	86	52.33 %	47.67 %	100 %
	Male	PRE	24	63	87	27.59 %	72.41 %	100 %
		POST	35	52	87	40.23 %	59.77 %	100 %
Traditional	Female	PRE	43	47	90	47.78 %	52.22 %	100 %
		POST	41	49	90	45.56 %	54.44 %	100 %
	Male	PRE	23	62	85	27.06 %	72 94 %	100 %
		POST	16	69	85	18.82 %	81.18 %	100 %

Frq.: Frequency.
Per.: Percentage.
S: Success
F: Failure
T: Total

Table 8.6 shows that the percentage of success increased in the cooperative groups and decreased in the traditional groups, especially in the male group.

A very important issue to be discussed here is the decrease of the percentage of the success in all groups, especially in the traditional male group. Teachers in those classes explained that this weakness was because of the standard of the questions in the pre-test and post-test and commented that the standard of the exams usually did not reach the standard of high level of thinking and most of the questions are in the standard of knowledge and computation, and comprehension. The students are not used to being examined in the standard of application and analysis because they have very weak ability in application and problem solving skills. Moreover, the policy in the Jordanian educational system did not allow teachers to let the percentage of failure increase more than 4 %; that is, in the classes containing 50 students, it is not allowed to give failure for more than two students and, hence, each year most of the students transfer automatically to the next stage and year after year the weakness increases and the standard of the students gets lower and lower. Sometimes, the teachers may give the students extra marks to help them a successful degree.

This one important issue explains the weakness of the students, especially in the upper basic primary stage. When the students enter the GCSE (General Certificate for Secondary Exam) they face the real situation and, consequently, the percentage of failure usually reach 50 % or more, especially in mathematics. This result supports the finding here and supports the need of such research to search for early solutions to the problem. Because of all that has been mentioned earlier the researcher decreased the percentage of success to 40% and re-calculated the percentage of success and failure (see tables 8.7, 8.8 and 8.9).

Table 8.7
Frequencies and percentage for the success and failure in the two experimental groups for the pre-test and the post-test in the total achievement
(Success score 40 % - 20/50)

Method	Gender	Test	Frq. S.	Frq. F.	Frq. T	Per. S	Per. F	Per. T
Cooperative	Female	PRET	21	65	86	24.42 %	75.58 %	100 %
		POT	58	28	86	67.44 %	32.56 %	100 %
	Male	PRET	40	47	87	45.98 %	54.02 %	100 %
		POT	46	41	87	52.13 %	47.13 %	100 %
Traditional	Female	PRET	50	40	90	55.56 %	44.44 %	100 %
		POT	49	41	90	54.44 %	45.56 %	100 %
	Male	PRET	36	49	85	42.35 %	57.65 %	100 %
		POT	31	54	85	36.47 %	63.53 %	100 %

Frq.: Frequency
Per.: Percentage.
S: Success
F: Failure
T: Total

Comparing the results in tables 8.6 and 8.7 indicates that reducing the percentage of success to 5% makes sense with the same findings. The percentage of the success increased in the cooperative groups and decreased in the traditional groups with statistically significant differences, especially in the male groups. For more explanation see tables 8.8 and 8.9.

Table 8.8
Frequencies and percentage for the success and failure in the two experimental groups for the pre-test and the post-test in the standard of knowledge and computation, and comprehension
(Success score 40 % - 10/25)

Method	Gender	Test	Frq. S.	Frq. F.	Frq. T	Per. S	Per. F	Per. T
Cooperative	Female	PREA	30	56	86	34.88 %	65.12 %	100 %
		POA	63	23	86	73.26 %	26.74 %	100 %
	Male	PREA	48	39	87	55.17 %	44.83 %	100 %
		POA	58	29	87	66.67 %	33.33 %	100 %
Traditional	Female	PREA	76	14	90	84.44 %	15.56 %	100 %
		POA	75	15	90	83.33 %	16.67 %	100 %
	Male	PREA	48	37	85	56.47 %	43.53 %	100 %
		POA	50	35	85	58.82 %	41.18 %	100 %

Frq.: Frequency.
Per.: Percentage.
S: Success
F: Failure
T: Total.

Table 8.9
Frequencies and percentage for the success and failure in the two experimental groups for the pre-test and the post-test in the standard of application and analysis
(Success score 40 % - 10/25)

Method	Gender	Test	Frq. S.	Frq. F.	Frq. T	Per. S	Per. F	Per. T
Cooperative	Female	PREB	21	65	86	24.42 %	75.58 %	100 %
		POB	60	26	86	69.77 %	30.23 %	100 %
	Male	PREB	36	51	87	41.38 %	58 62 %	100%
		POB	40	47	87	45 98 %	54.02 %	100 %
Traditional	Female	PREB	42	48	90	46.67 %	53.33 %	100 %
		POB	42	48	90	46.67 %	53.33 %	100 %
	Male	PREB	27	58	85	31.76 %	68.24 %	100 %
		POB	29	65	85	23.53 %	76.47 %	100 %

Frq.: Frequency.
Per.: Percentage.
S: Success
F: Failure
T: Total

Comparing the percentages in the two previous tables illustrates how the standard of the questions affect students' achievement. The percentage of success in all cooperative and traditional groups in the standard of knowledge and computation, and comprehension are definitely more than those percentages in the standard of application and analysis. This indicates, and supports the previous findings, that there is a weakness of the students in all groups in mathematical application and problem solving skills. Actually, teaching mathematics in Jordan still deals with it as an abstract subject and does not apply it as a practical science.

Another important finding to be noted is that, in spite of this weakness, male cooperative groups achieved more than the male traditional groups in all standards. The female groups achieved more the male groups and, despite that, the achievement of the traditional female groups were more than the female cooperative groups. The progress of the cooperative female groups before and after the experiment support the positive effect of this method in students' mathematical achievement especially in application and problem solving skills. There is no real effect on the traditional method of teaching in the female group while a negative effect in this method was noticed in the male group with statistically significant differences in the standard of application and problem solving skills.

Findings in table 8.8 highlight the positive effect of cooperative learning on promoting the students' outcomes in the standard of knowledge and understanding. Although the percentage of the success gradually decreased in the female traditional group and gradually increased in the male traditional group, previous statistical techniques (see table 8.5) indicate that there are no statistically significant differences in the standard of mathematical achievement.

Summary of previous quantitative findings in the pre-test / post-test assessment

All previous findings indicate that there are statistically significant differences in students' performance related to methods of teaching and gender and no statistically significant differences related to the effect of the interaction between teaching method and gender except in the standard of application and analysis. Female students achieved more than the male groups. Although the female traditional groups achieved more than the female cooperative group in their post-test, other statistical techniques (paired sample t-test) indicate the positive effect of cooperative learning in promoting students' achievement in all standards before and after the experiment. There was no real effect on the traditional teaching method in promoting students' achievement in the two female and male groups except in the male group; this method affected negatively in the students' achievement in the standard of application and analysis. The effect of the pre-achievement test on the post-achievement test has a real effect with statistically significant differences in the standard of application and analysis and in the total achievement and no real effect of the pre-test on the post-test in the standard of knowledge and computation, and comprehension.

b) The questionnaire (part one)

Assess students' perspectives and beliefs about teaching method effects on achievement and problem-solving skills

Since the previous quantitative findings illustrate that cooperative learning has a positive effect on the students' mathematical achievement especially in the standard of application and analysis, it was necessary to use other instruments to assess how this strategy affects positively, and why. Moreover, there was a need to assess students' and teachers' views about using cooperative learning versus the traditional teaching methods to explore other skills that may be developed during the implementation of the experiment and those that can not be measured or tested quantitatively by using tests.

The second instrument used in the quantitative part for this issue was the first part of the questionnaire (appendix three, part one) which assessed students' perspectives and beliefs about the effects of the teaching method on their mathematical achievement and problem solving skills.

Mean and standard deviation for the parts of the questionnaire were calculated statistically (see table 8.10).

Table 8.10
Mean and standard deviation of the parts of the questionnaire in the two experimental groups

Method	Gender		Part 1	Part 2	Part 3	Part 4	Part 5
Cooperative	Female	Mean	4.1512	3.5930	3.3721	3.5233	1.3214
		Std. Dev.	.6234	.5397	.8124	.5024	.4698
	Male	Mean	3.8837	3.5814	3.7674	3.5814	1.2442
		Std. Dev.	.5825	.5626	.6449	.5416	.4321
	Total	Mean	4.0174	3.5872	3.5698	3.5523	1.2824
		Std. Dev.	.6163	.5498	.7577	.5216	.4515
Traditional	Female	Mean	3.1667	3.0667	3.1444	3.3222	1.3667
		Std. Dev.	.6746	.5959	.6961	.4699	.4846
	Male	Mean	3.1647	3.2706	3.2706	3.2824	1.5529
		Std. Dev.	1.0100	.6617	.9806	.6476	.5001
	Total	Mean	3.1657	3.1657	3.2057	3.3029	1.4571
		Std. Dev.	.8516	.6351	.8462	.5620	.4996
Total	Female	Mean	3.6477	3.3239	3.2557	3.4205	1.3448
		Std. Dev.	.8147	.6258	.7616	.4950	.4767
	Male	Mean	3.5263	3.4269	3.5205	3.4327	1.3977
		Std. Dev.	.8965	.6317	.8632	.6135	.4909
	Total	Mean	3.5879	3.3746	3.3862	3.4265	1.3710
		Std. Dev.	.8569	.6299	.8228	.5558	.4838

Since there are differences in the mean and the standard deviations, multivariate analysis of variance (MANOVA) was used just to assess if there are statistically significant differences of the students' responses toward the parts of the questionnaire (as a dependent variable) related to the effect of teaching method, gender and the interaction between teaching method and gender (as independent variables) (see table 8.11).

Remark: for the affect of the interaction between teaching method and gender see appendix nine (b).

Table 8.11
Multivariate analysis of variance of the students' responses in the two experimental groups toward the parts of the questionnaire according to the method of teaching and gender

Source of variance	Dep. Var.	Sum of squares	D f	Mean Square	F	Sig.
Corrected Model	Part 1	66.173a	2	33.086	60.446	.000
	Part 2	15.874b	2	7.937	22.501	.000
	Part 3	17.323c	2	8.662	13.689	.000
	Part 4	5.399d	2	2.699	9.144	.000
	Part 5	2.909e	2	1.454	6.409	.002
Intercept	Part 1	819.780	1	819.780	1497.664	.000
	Part 2	545.974	1	545.974	1547.816	.000
	Part 3	527.648	1	527.648	833.882	.000
	Part 4	494.380	1	494.380	1674.596	.000
	Part 5	41.825	1	41.825	184.328	.000
Method	Part 1	64.741	1	64.741	118.276	.000 *
	Part 2	14.815	1	14.815	41.999	.000 *
	Part 3	11.148	1	11.148	17.618	.000 *
	Part 4	5.384	1	5.384	18.236	.000 *
	Part 5	2.668	1	2.668	11.757	.001 *
Gender	Part 1	1.846	1	1.846	3.372	.067
	Part 2	.905	1	.905	2.565	.110
	Part 3	5.843	1	5.843	9.234	.003 *
	Part 4	5.752E-03	1	5.752E-03	.019	.889
	Part 5	.274	1	.274	1.208	.273
Error	Part 1	187.201	342	.547		
	Part 2	120.637	342	.353		
	Part 3	216.404	342	.633		
	Part 4	100.966	342	.295		
	Part 5	77.602	342	.227		
Total	Part 1	4703.000	345			
	Part 2	4057.000	345			
	Part 3	4188.000	345			
	Part 4	4156.000	345			
	Part 5	729.000	345			
Corrected Total	Part 1	253.374	344			
	Part 2	136.510	344			
	Part 3	233.728	344			
	Part 4	106.365	344			
	Part 5	80.510	344			

* Significant ($p < 0.05$).
Dep. Var.: Dependent variable.
F: F value.
d f : Degree of freedom.

Table 8.11 (with respect to part one of the questionnaire) reveals that:

1. There are statistically significant differences in the students' response to part one, relating to the method of teaching.

Comparing means in table 8.10 indicated that the mean of the total cooperative group was more than the mean of the total traditional group (4.0174 > 3.1657) with statistically significant differences. This means that cooperative learning affects positively more than traditional teaching methods for this part of the questionnaire. In addition, it reveals that the students in the cooperative group mostly agree that cooperative learning effects positively on their mathematical achievement and problem-solving skills. Also, students in the traditional group were uncertain of the effects of the teaching method on their mathematical achievement and problem-solving skills. This finding supports the finding in the pre-test/post-test assessment which is that cooperative learning affects positively in promoting mathematical achievement and problem-solving skills while there is no effect of the traditional teaching methods on students' mathematical achievement in all standards except in the male group in the standard of application and analysis. The mean of the students male traditional group was 3.1647 which also indicates that they were mostly uncertain about the effect of the teaching method used, while this method affects negatively on their mathematical achievement in this standard. Since there are no gender differences in part one of the questionnaire, comparing female and male cooperative and traditional groups does not make sense (table 8.11). Previous findings indicate that:

- Hypothesis 10. H0 is rejected.
- Hypothesis 10. H1 is accepted.

Remark: for hypothesis 10.H0 and 10.H1 see page 141.

2. No statistically significant differences related to gender (Sig. 0.067 > 0.05), hence:

- Hypothesis 11. H0 accepted.
- Hypothesis 11.H1 rejected.

Remark: for hypothesis 11.H0 and 11.H1 see page 142.

That means that there are no gender differences in students' beliefs about the effect of the teaching method on their mathematical achievement and problem solving skills. This result reveals that students' beliefs and perspectives between female and male groups does not strongly relate to the results found in the pre-test/post-test assessment while there were statistically significant differences related to gender on students' mathematical achievement in all standards and generally female achieve more than male students. However, comparing means in table 8.10 shows that students in the female cooperative group believe that the teaching strategies affect more positively on their mathematical achievement and problem-solving skills than in the female traditional group. Also, students in the male cooperative group believe that the teaching strategies affect more positively on their mathematical achievement and problem-solving skills than the traditional male group.

1. There are statistically significant differences on students' response towards part one of the questionnaire related to the interaction between teaching method and gender (see appendix nine (b)).

Comparing means in table 8.10 show these differences. While the means of the female and male traditional groups are nearly the same (3.1667 and 3.1647, respectively), the mean of the female cooperative group is more than the mean in the male cooperative group. This means that students in the female cooperative group believe that cooperative teaching strategies affect more positively than the male cooperative groups. This supports the findings of the study for the pre-test / post-test results where the progress of the female cooperative group was more than those in the male cooperative group. However, female and male cooperative groups believe that teaching strategies affect more positively in the mathematical achievement than those in the female and male traditional groups. Previous findings indicate that:

- Hypothesis 12. H0 is rejected.
- Hypothesis 12. H1 is accepted.

Remark: for hypothesis 12.H0 and 12.H1 see page 142.

The previous statistical techniques represent initial evaluation. For more explanation the frequencies and percentages calculated for the items of the first part see table 8.12.

This to give the researcher and the reader more judgement on students' response towards these items and to discuss how cooperative learning strategies affect more positively in students' mathematical achievement and problem solving skills than the strategies in the traditional classes.

Table 8.12
Frequencies and percentage of the students' response (agreement, uncertainty and disagreement) towards the items of part 1 of the questionnaire

Part One: Students' perspectives about teaching method effects on achievement and problem-solving skills.

Item	TM	G	Students' response					
			Agreement		Uncertainty		Disagreemeet	
			Frq.	Per.%	Frq.	Per.%	Frq.	Per.%
1. Teaching method develops the mathematical knowledge of me.	C	F	73	84.88	7	8.14	6	6.98
		M	79	91.86	1	1.16	6	6.98
	T	F	57	64.77	4	4.55	27	30.68
		M	55	64.71	6	7.06	24	28.24
2. Teaching method does not increase my understanding for the difficult concepts.	C	F	58	69.88	11	13.25	14	16.86
		M	57	66.28	9	10.47	20	23.26
	T	F	46	51.69	9	10.11	34	38.20
		M	23	27.06	11	12.94	51	60.00
3. Teaching method helps my higher achievement in mathematics.	C	F	62	75.61	13	15.85	7	8.54
		M	58	67.44	12	13.95	16	18.60
	T	F	48	53.93	13	14.61	28	31.46
		M	51	60.71	6	7.14	27	32.14
4. Teaching method encourages me to use the new mathematical vocabulary words properly.	C	F	67	80.72	8	9.64	8	9.64
		M	72	83.72	5	5.81	9	10.47
	T	F	50	56.18	11	12.36	28	31.46
		M	39	45.88	12	14.12	34	40.00
5. Teaching method helps me to understand the mathematical principles and rules.	C	F	66	76.74	11	12.79	9	10.47
		M	74	87.06	7	8.24	4	4.71
	T	F	47	53.40	12	13.64	29	32.95
		M	45	53.57	8	9.52	31	36.90
6. Teaching method increases my ability to use the concepts and rules to solve mathematical problems.	C	F	66	79.52	7	8.43	10	12.05
		M	70	81.40	10	11.63	6	6.98
	T	F	56	62.22	10	11.11	24	26.67
		M	42	49.41	12	14.12	31	36.47
7. Teaching method does not teach how to transfer the concepts and skills in new situations and problems.	C	F	9	10.59	4	4.71	72	84.71
		M	37	43.02	14	16.28	35	40.70
	T	F	43	47.78	3	3.33	44	48.89
		M	13	15.29	12	14.12	60	70.59
8. Teaching method does not help me in doing mathematical proofs.	C	F	68	80.00	4	4.71	13	15.29
		M	65	76.47	3	3.53	17	20.00
	T	F	46	51.11	12	13.33	32	35.56
		M	32	37.65	10	11.76	43	50.59
9. Teaching method introduces the strategies and algorithms for solving the mathematical problems in a simple way.	C	F	76	88.37	7	8.14	3	3.49
		M	72	84.71	7	8.24	6	7.06
	T	F	47	52.22	11	12.22	32	35.56
		M	58	68.24	7	8.24	20	23.53

10. Teaching method does helps me to explain how the new information relates to previously mastered mathematical skills and concepts.	C	F	55	63.95	1	1.16	30	34.88
		M	63	73.26	10	11.63	13	15.12
	T	F	34	38.64	6	6.82	48	54.55
		M	27	31.76	11	12.94	47	55.29
11. Teaching method helps me understand the mathematical problem and to explore a solution for it.	C	F	73	85.88	4	4.71	8	9.41
		M	72	84.71	8	9.41	5	5.88
	T	F	38	42.22	8	8.89	44	48.89
		M	48	56.47	13	15.29	24	28.24
12. Teaching method leads me to expect the primary solution.	C	F	62	72.94	4	4.71	19	22.35
		M	60	69.77	13	15.12	13	15.12
	T	F	48	53.93	5	5.62	36	40.45
		M	34	40.00	13	15.29	38	44.71
13. Teaching method increases my skills in computations.	C	F	74	88.10	5	5.95	5	5.95
		M	73	85.88	8	9.41	4	4.71
	T	F	52	57.78	15	16.67	23	25.56
		M	50	59.52	10	11.90	24	28.57
14. Teaching method does not help me to collect data and choose algorithms to organise it in solving the problems.	C	F	10	11.90	7	8.33	67	79.76
		M	21	24.42	12	13.95	53	61.63
	T	F	33	36.67	7	7.78	50	55.55
		M	33	38.82	16	18.82	36	42.35
15. Teaching method lets enables me to translate the word problems into mathematical problems.	C	F	76	89.41	3	3.53	6	7.06
		M	53	61.63	7	8.14	26	30.23
	T	F	30	34.09	7	7.95	51	57.95
		M	53	62.35	14	16.47	18	21.18
16. Teaching method helps me to link the mathematical subjects with different life situations.	C	F	62	72.94	4	4.70	19	22.35
		M	55	63.95	8	9.30	23	26.74
	T	F	33	36.67	15	16.67	42	46.67
		M	25	29.41	12	14.12	48	56.47
17. Teaching method increases my ability to use the mathematical skills to solve some of the daily life applications.	C	F	69	80.23	5	5.81	12	13.95
		M	66	76.74	12	13.95	8	9.30
	T	F	42	47.73	28	31.82	18	20.45
		M	55	64.70	6	7.06	24	28.24
18. Teaching method helps me to understand other subjects such as science and geography.	C	F	72	84.71	3	3.53	10	11.76
		M	54	62.79	12	13.95	20	23.26
	T	F	53	58.89	12	13.33	25	27.78
		M	50	58.82	13	15.29	22	25.88
19. Teaching method offers a solution for my weakness in solving problems.	C	F	60	70.59	12	14.12	13	15.29
		M	65	75.58	6	6.98	15	17.44
	T	F	30	33.33	12	13.33	48	53.33
		M	30	35.29	15	17.65	40	47.06
20. Teaching method promotes my ability to solve the mathematical problems in a successful way.	C	F	67	77.91	11	12.79	8	9.30
		M	67	77.91	9	10.47	10	11.63
	T	F	52	57.78	13	14.44	25	27.78
		M	52	61.18	10	11.76	23	27.06

TM: Teaching method.
G: Gender.
C: cooperative.
T: Traditional.
F:Female.
M:Male.

Table 8.12 presents students' beliefs and perspectives about how teaching methods and strategies affect their mathematical achievement and problem solving skills. As was mentioned in chapter three of this study, the mathematical structure consists of concepts, rules and generalisation, algorithms and skills and, finally, problem solving. Problem solving is the heart of mathematics because it reflects students' ability to use the previous concepts, rules and algorithms that were learned, understood and stored in their memory to provide a solution for a new situation with different techniques and stages involved during solving the problem (discussed in detail in chapter three). This part of the questionnaire represents the frequencies and percentage of the students' response towards each item of this part.

1. Items 1, 2 and 3 indicate that, while nearly 65% of the students in the traditional group believe that teaching strategies involved in their classes develop mathematical knowledge for them, nearly 85% of the female students and 92% of the male students have such perspectives in the cooperative group. This highly supports the more positive effect of cooperative learning to develop the mathematical knowledge of the views of students than those in the traditional group. On the other hand, students in the female and male cooperative groups agreed more than those in the traditional group that teaching methods participate in enhancing their mathematical achievement, respectively, with large differences in the female group. Items 1 and 3 illustrate that students in the two groups were mostly satisfied with the teaching method involved with more satisfaction in the cooperative group where this method develops the mathematical knowledge and participates in enhancing the achievement. With respect to students' response in the traditional group, the qualitative analysis will give explanations about this issue. It was found that most students in their classes are satisfied with their teachers' skills, especially in the male group, which explains their response in the questionnaire. Also, this supports the findings in the previous quantitative parts, especially in the traditional teaching method, where there was no negative affect of this teaching method on students' achievement and a positive effect, due to applying cooperative learning. With respect to the differences in students regarding the teaching method involved, it is clear that students in cooperative learning are in more agreement than those in the traditional group that teaching methods affect their progress in mathematics achievement positively and that is also supported by

previous findings. It seems in item 2 that there is some contradiction but, actually, with a deeper look, this can be explained by the fact that, in using cooperation learning it is sometimes quite difficult for the students to teach each other the difficult and complex concepts. Teaching difficult concepts may need more discussion and explanation from the teacher which is more available in the traditional situations (which can be described as teacher-centred approach) than in cooperative classes (which can be described as student-centred approach). Actually, students' response in the male group may relate to the effect of the teachers' characteristic and their teaching skills. It was found that male students in the traditional group were satisfied with their teachers' ability to discuss the difficult concepts and problems and introduce several solutions for it. This point will be highlighted through the next stages of the qualitative part of the study. It could be said that students' response to cooperative learning was mostly in agreement with the items of the questionnaire because they might be more enthusiastic to apply the new method. It is obvious here that the percentage of agreement in the other two items for this point are higher than this item. This indicates that they are aware of their answers.

2. Items 4, 5, 6 and 7 show that cooperative learning has a positive effect in allowing students a higher opportunity to use new mathematical vocabulary properly than those in the traditional classes. This was actually observed during the interaction within groups which gave more chance for them to speak mathematically. Also, it raises the effects of cooperative learning strategies in helping students to understand the principles and rules, to use these concepts and rule in solving problems and to teach them how to transfer the concepts and the skills in new situations more than the students in the traditional groups. These are basic skills in promoting problem-solving skills in mathematics and give a clear explanation of how cooperative learning affects positively in promoting problem solving skills in mathematics. Moreover, most students in the two experimental groups agree that the teaching methods are more effective than the students who disagree, except the male students in item 7. This supports the hypothesis that the traditional teaching method did not affect negatively, but cooperative learning positively affected compared with the traditional methods. This also highlights the point that teaching skills were at a

high level where most students were satisfied with these skills in teaching. A detailed discussion of the students' views towards the teaching method and the effect of the teacher' characteristics and its relation to the findings of the study will be given in the qualitative part of the analysis. The differences arising in the male groups in item 7 can be explained relating to the teachers' mathematical skills and the teachers' role in introducing different kinds of problems and different procedures in solving them in the traditional classes and where the teachers have more opportunity and enough time to speak and discuss rather than in the cooperative group where there is more participation of the students.

3. Item 8 shows than more than 50% in all groups, except the male traditional group, agree that teaching strategies do not help them to do mathematical proofs; the percentage in the cooperative groups is more than the traditional groups, while, in the traditional male group, nearly 51% of the students disagree with this item. This highlights the point that the traditional teaching method is more effective in enabling the students to do mathematical proofs than the cooperative learning method. This is an important issue when the students face problems in mathematical proof and cannot teach others and explain the steps to others as the teachers can. Therefore, these kinds of mathematical skills need the assistance of the teacher more than the assistance of the students. One teacher in the cooperative group commented that he noticed that this method was less effective in the circle unit while, in other subjects, it was very effective. He explained that this was because problems in this unit mostly need deep thinking to prove mathematical rules or statements. Also, it needs many continuous procedures to find out the solution. He found that group-mates were less interactive and cooperative in such types of mathematics subject to understand the problems and find solutions for them. The response of the male traditional students may be strongly related to the teaching skills.
4. Item 9 and 10 show how effectively cooperative learning introduces the strategies and algorithms for solving mathematical problems in a simple way and helps students to explain how the new information relates to the previously mastered mathematical skills and concepts compared with the traditional teaching methods. This may reflect that teachers in cooperative learning

introduce the basic ideas and basic skills and give the students more chance to participate and share ideas for solving the problems and exploring the solutions. During the group work students explain to each other how the new information relates to the previously mastered mathematical skills and concepts. The situation in the traditional teaching method is different where it is dependent on the teacher to introduce most strategies and algorithms for solving problems. So, they found that it is not introduced in a simple way. Moreover, students were in less agreement than those in the cooperative learning groups that the teaching method helps them to explain how the new information relates to previously mastered mathematical skills and concepts. This can be referred to the fact that teachers in the traditional classes have no more time to review all the previous mathematical skills ands concepts (as will be discussed in the next qualitative analytical stages).

5. Items 11, 12, 13, 14 and 15 reveal how the cooperative learning strategies positively effected more than the traditional strategies in promoting some of the mathematical problem-solving in helping students to understand the problem, to explore its solutions, to expect the primary solution, increase computational skills, collect data, choose algorithms and organise these data for solving the problem and giving students more skills in translating word problems into mathematical ones. Actually, if students in mathematics classes mastered such skills it could be said that they are problem-solvers.
6. Items 16, 17 and 18 indicate that students in cooperative learning believe that the teaching method helps them to link the mathematical subjects to different life situations and to understand other subjects, such as science and geography. Also, they believe that their ability to use the mathematical skills to solve some of the daily life applications were increased more than students in traditional classes. Actually, it was found that teachers in the two experimental groups used not to link the mathematical material with different life situations and other subjects (this will be highlighted in other parts of the analytical stages). This indicates the positive effect of applying cooperative learning method compared with the traditional methods to enhance students' ability to link the mathematics subject with different life situations. This result supports the previous findings especially in the female group where students reached a high standard of application and analysis.

7. Items 19 and 20 generally illustrate that students in the cooperative learning classes have more agreement that those in the traditional classes, that teaching strategies offer a solution for their weakness in solving mathematical problems. Moreover, they feel more than those in the traditional classes that they make progress to solve the mathematical problems successfully.

Summary of previous quantitative findings in part one of the questionnaire

The previous findings in the first part of the questionnaire, which is designed to assess students' perspectives about the effects of teaching strategies on their mathematical achievement and problem solving skills, indicates that the students in cooperative learning are more satisfied than those in the traditional classes that teaching strategies help to increase their mathematical achievement and promote their problem-solving skills with no gender differences. However, students in the traditional classes are satisfied with teaching strategies involved in their classes. That supports the previous quantitative analysis of the pre-test / post-test assessment that traditional teaching methods have no negative effects on the students progress except in the male traditional classes in the standard of application and analysis.

Within these findings a higher satisfaction of the traditional strategies in some situations supported the high level of teaching skills especially in the male traditional group. However, more explanation to answer the question why the traditional teaching methods effected so negatively on male students in the standard of application and analysis will be given later, in the next stages of the analysis parts.

Analysis of the items in the first part of the questionnaire showed how cooperative learning strategies help more than the traditional teaching strategies in increasing the students' achievement and promoting their problem solving skills. This exploration arises through the positive effects of cooperative learning in developing students' mathematical knowledge, enabling them to speak mathematically and use new mathematical vocabulary, helping them in understanding mathematical concepts and rule, collecting data, choosing suitable algorithms, organising them in solving problems and giving them ability to transfer these skills to new situations. It helps them to understand the problem to be solved, explore a solution for it and expect the primary solution. Moreover, it increases other skills, such as the computation. Cooperative learning increass students' ability to translate word problems into mathematical ones and solve real-life applications. It offers a solution for students' weakness and enhances their abilities in solving problems successfully.

On the other hand, this part explores some situations where the effects of the traditional teaching strategies may be more effective. More explanation and discussion from the teacher is needed if these situations cannot be understood easily by the students during their group-work. These situations need the teacher-centred approach more than the student-centred learning, such as discussing difficult concepts, doing and understanding mathematical proofs. This is because teachers in the traditional classes may have enough time to speak and discuss more than in the cooperative classes where there is most time for students work and exploration. On the other hand, it may depend on the teachers' skills in the mathematics classroom. The teaching and learning process is complex where different factors affect students' outcomes. However, this research assesses the effects of cooperative learning versus the traditional one without ignoring other factors that may affect the teaching and learning process.

The Qualitative Part

Previous quantitative data analysis for the pre-test / post-test assessment design illustrated that cooperative learning strategies positively affect promoting students' mathematical achievement and problem-solving skills in all standards of behaviour and objectives in the cognitive domain, while there was no real effect from the traditional teaching methods on promoting such achievement, except in the standard of application and analysis, where its effect was negative in the male traditional group. Moreover, quantitative data analysis for the first part of the questionnaire supports previous findings relating to the students' perspectives and beliefs about the effect of the teaching method on their mathematical achievement and problem solving skills.

Results showed that students in the cooperative learning group mostly believe and agree that the teaching method positively affected promoting their problem solving skills and achievement in mathematics, while the traditional group was mostly uncertain about the effect of the method involved. Most items of the questionnaire explored how the cooperative learning strategies positively affected their mathematical achievement and problem-solving skills versus the traditional ones. A few items of the questionnaire relating to students' perspectives and beliefs show that, sometimes, the traditional teaching method increases some mathematical skills. However, these responses in the male traditional group contradict their real scores in the pre-test / post-test achievement. To answer the questions that could not be tested and answered by the quantitative analysis part and to illuminate the previous findings, the researcher had a good deal of the qualitative data collected for more investigation and exploration to assess how the cooperative learning strategies affected promoting students' mathematical achievement and problem solving skills versus the traditional teaching methods, and why. The data collected within this part includes interviews with students, interviews with teachers and field notes reported by the researcher herself during the class visits within the experiment.

a) Interviews with students

The interviews conducted were face-to-face meetings between the researcher and the students at the end of the experiment. This method had more advantages than the questionnaire because it can be used to obtain information from students who may have difficulties or confusion with the wording of the questionnaire. Moreover, interviews present a success rate in obtaining responses from the students and obtaining more information and ideas that require sequencing. As was discussed in chapter seven, the interviews with students took place in their classes. The questions of the interviews were conducted as a series of questions by using open discussion. The questions were presented in detail in chapter seven. Within the analytical stage, the questions related to each issue to be highlighted will be written separately in order to make it easy for the reader to follow up the analysis of the data collected.

Students' views about their performance in mathematics and their ability in problem solving skills

- **Does the teaching method increase the cognitive and competitive atmosphere? If yes, how? If no, why?**

Students' responses towards the previous question varied from one to another. All students interviewed in the female and male cooperative groups agreed that cooperative learning increased the cognitive and competitive atmosphere within the classroom. They commented that working in groups created a competitive atmosphere within the groups of the class through the competitions that were conducted, especially in the unit review lessons. This encouraged them to work hard within their groups and to interact and help other members of the group. In addition, mastering the material to make more progress in the quizzes as a whole in order to get the reward helps to increase students' interaction to help each other, master the material and support each other with the assistance needed to encounter difficulties in solving problems; moreover, gaining new information and different proposed solutions. All of these factors contribute to increase the cognitive atmosphere. Some of these responses are quoted below.

> " Yes, with respect to the cognitive atmosphere during group work all of the girls participate and interact to solve the problems, so they teach each other and I may gain new information from them that I may forgot it or missed understand it. And day after day I learned more and more..."
>
> Male student, cooperative group.

> "... In the cooperative learning all group members in each group work hard and help others in order to put their group name on the bulletined board to get extra scores. This creates the competitive feeling between the groups."
>
> Female student, cooperative group.

> " Of course, because some new students enter the competition field".
>
> Male student, cooperative group.

> " ... Yes, for example, if someone does not know anything in mathematics she will learn from her group mates."
>
> Female student, cooperative group.

> "Yes, the competition is not only between high achieving students, but all students compete between other"
>
> Male student, cooperative group.

> " Yes, yes. Every student can prove his worthiness in his group because the teacher used to give us more incentives and extra marks for students who answer quickly. Yes, I think this was a main reason to increase the cognitive atmosphere in the class because most students participate in the lessons."
>
> Female student, cooperative group.

In the traditional group some students agree that the traditional teaching method increases the cognitive and competitive atmosphere (4 out of 12 females and 5 out of 12 males). In the male traditional group they pointed out that the teachers discussed the material in an excellent way and introduced several examples and if any student asked about any point the teacher would repeat the solution again. The competitive atmosphere arises when the students' write their answers on the board and that raises some kind of competition with the students who participate in solving problems. Female traditional students commented that, sometimes, the teachers made competitions between some girls on the board to solve some problems but this was done in the easy and short lessons and a limited number of students used to participate in these competitions. They felt that their mathematical cognitive was increased because of the teachers' discussion in the lessons and giving new information. Some of these responses are given below.

> " Yes, sometimes. The student who raises his hand goes to the board to solve the problem."
>
> Male student, traditional group.

> " Yes, I felt that but a little bit because it takes more time to make competitions. However, the teacher's method in solving problems is different from one to another and I felt that the teacher's method is better than the previous one because he always tries to give us more examples that increase the cognitive atmosphere."
>
> Male student, traditional group.

> " Yes, sometimes if the lesson was easy and short the teacher made a competition on the board but a limited number of girls participated in solving. "
>
> Female student, traditional group.

> "...With respect to the cognitive atmosphere, since the teacher discusses and gives us new lessons, so we will learn more and increase our cognitive."
>
> Female student, traditional group.

> " Whenever the student enters a new grade he will gain more information and hence his academic standard will become more."
>
> Female student, traditional group.

Most students in the female and male traditional classes who believe that the teaching method does not increase the cognitive and competitive atmosphere referred to the following reasons.

First: fewer opportunities for most students to participate. In these classes a limited number of students always participate in solving problems when the teacher asks them to go to the board while most students sit on their chairs with no interaction or participation. This atmosphere gave no chance for low achieving students to participate and to enter the competitive domain.

Second: the fear of failure in solving problem in front of the class which may lead to feel disappointed and shy. Some students felt that the mathematical subjects always became more difficult than before and they faced many problems in understanding mathematics. In addition, because of its difficulty they are afraid to go to the board to solve problems because they may not able to solve the problems and then they will feel disappointed and shy.

Third: fewer opportunities for teachers to answer all students' questions.

Examples of these comments are written below.

> " No, the competition was always restricted to some students who always participate..."
>
> Male student, traditional group.

> " Occasionally, I felt afraid to answer questions on the board or in front of the girls. So I did not like to participate in the class."
>
> Female student, traditional group.

> " The competitive atmosphere exists but for high achieving students."
>
> Male student, traditional group.

> " Not so much, because of some difficult problems that I did not understand it, I could not ask all the questions to the teachers."
>
> Female student, traditional group

> "...Mathematics is difficult and the teacher has not enough time to answer all of our questions."
>
> Male student, traditional group.

- **Do you think that your achievement is getting better? Why?**

Data analysis of questions exploring students' views about their achievement progress showed that most students in the cooperative learning group (19 out of 24) felt that their achievement was getting better. Some of them pointed out that this was because of the interaction and cooperation through the discussion for solving the problems and achieving their group task. The cooperative situation which used not to be noticed in the traditional classes gave students a good opportunity to get information from each others, discuss ideas, share materials, ask questions and introduce different procedures and algorithms for solving problems. So, this environment developed their understanding of mathematics and because of that they felt that their achievement was getting better in their cooperative classes. Some of them said:

> " Yes, of course because in the group work we cooperate with each other to solve the problems and we help others. If any girl did not understand anything, her group mates discuss and explain to her how to solve the problems. Day after day I felt that mathematics is getting easer than before and my achievement increased."
>
> Female student, cooperative group.

> " Yes, the cooperative environment encouraged us to present different ideas, discus our problems, solve them in different methods, correct our answers and evaluate them."
>
> Male student, cooperative group.

> " Yes, yes. In the past we used to depend most of the time on our teacher to give us the solutions, but in cooperative learning we depend on ourselves most of the time and because of that I felt that my achievement is in progress."
>
> Female teacher, cooperative group.

Most students in the cooperative group who believe that their achievement depends on their scores commented that they felt that their achievement was getting better because their scores in the quizzes and some exams had increased within the period of the experiment. Others commented that they did not know exactly if the teaching method would positively enhance their achievement or not because they had no confidence in their own answers; even more they did not expect how they may succeed in the final achievement test. Some examples of these responses are given below.

" Yes, for example in the last month I got 8/25 and in this month I got 18/25. With respect to my scores really there were differences in my achievement".

Female student, cooperative group.

" I don't know, we did not take the final achievement test yet but I feel I may get higher marks than before".

Male student, cooperative group.

" Yes, especially the scores, within the period of the experiment I felt that I loved mathematics more and more and my scores were getting better and better."

Female student, cooperative group.

Students' responses in the traditional classes were different from one to another. A few of the traditional female students, those who believe that their achievement is getting better (6 out of 24), revealed their good ability and background in mathematics and there were always good girls/boys in mathematical lessons. Some of them referred to their teachers' skills in introducing the lesson, simplifying the questions and linking the material to previous mathematical skills that had been taught previously. Some students mentioned that they get assistance from their parents and others take special tutorials with a tutor because within the class the teacher cannot deal with all students and there is not enough time to correct their solutions and give them enough feed back. Actually, during the interview not one of them paid any attention to the effect of the teaching method as a traditional one. Some examples of these comments are mentioned below.

" Yes, I 'm always a good girl in mathematics. I find it so easy and my achievement is always in progress."

Female student, traditional group.

" Yes the teacher discusses the material in a good way and I think that I understand her discussion and my achievement increased."

Male student, traditional group.

" Yes, my achievement is quite getting better.... Because I take a tutorials with a mathematical tutor... because the teacher can not follow all of us within the class."

Male student, traditional group.

During the qualitative analytical part about students responses in the traditional group the researcher found that students who felt that they had progressed in their mathematical achievement insinuated that it was their teachers efficiency in discussing the material, especially in the male traditional classes. Most students who were interviewed commented that they have a good relationship with their teachers because they introduced the lesson in a good way and always try to present several types of solutions. One student commented that their teacher is very funny and makes a kind of joking in the class. The situation in the female traditional group was quite similar but in a different way. Students in one class commented that their teacher stimulated good discussion and sometimes she made some kind of competitions between the girls. Nevertheless, most students in this group (18 out of 24) believe that their achievement did not increase. It may still be the same as before or it may decrease. The referred that to different reasons such as: difficulty of the material, fewer opportunities for students in participation and fewer opportunities for teachers to evaluate students' solutions and feed them back. Actually, the above investigations give a satisfying answer to the students' responses in this issue in the first part of the questionnaire. Some examples of students' responses in the traditional group are given below.

> " I think my achievement is less than before because the material is getting to be more difficult...I cannot understand mathematics alone and I need someone to help me"
>
> Male student, traditional group.

> " Well, although the teacher's discussion is very good and he introduces several kind of solutions, I feel that I didn't get more achievement because the teacher can not follow all of us."
>
> Male student, traditional group.

> " I feel that mathematics is a difficult subject. I have some difficulties in understand the problem and it may take of me a lot of time to understand it and begin to solve it. Because of that, I feel that I have no chance to participate and my achievement is getting worse."
>
> Male student, traditional group.

> " I don't know, may be the same... because nothing is different than before."
>
> Female student, traditional group.

> " No, it doesn't because I have no chance to participate in the class. If I solved the problems, I don't know if my solution is right or wrong. And because there is no one who can help me in mathematics my score is less than before."
>
> Female student, traditional group.

" Oh, sometimes. Actually it depends on the material of the exam. If it is easy, I may get high marks. But usually no."

Male student, traditional group.

" Actually, the teacher teaches us in a good way, she sometimes make some competition on the board but few girls who always participate in the class contribute in such competition. But for me, I feel that nothing is new in my achievement."

Female student, traditional group.

- **Have you noticed that the teaching method affects your ability in solving problems? If yes, how? If no, why?**

The last question in this investigation was to assess students' views about the effect of the teaching method in promoting problem-solving skills. Most students in the cooperative learning group (22 out of 24) felt that their skills in solving mathematics increased. Some of them commented that they felt that cooperative learning encouraged and motivated them to challenge the mathematical problems and try to solve them. Moreover, the cooperation within the group facilitates the steps they follow in solving problems. These include reading and understanding the problem, drawing graphs or figures, devising and carrying out the plan for solving the problem. Only two male cooperative students still found it difficult to solve the problems especially if it is a mathematical proof. Some of these responses are given below.

"Yes it improved my standard in solving problems because I must depend on myself with the help of my group mates without depending on the teachers to answer as it was in the traditional method."

Male student, cooperative group.

" The skills increased. In the past, we used to get the answers directly from the teacher or we may get it from a mathematical course. Now, we discuss the question and solve it within our group."

Male student, cooperative group.

" Of course increased. I began to like mathematics and the cooperative method encouraged me to challenge the mathematical problems."

Female student, cooperative group.

" Yes, because I got the benefits from my group and also they got benefits from me."

Female student, cooperative group.

> " Yes, because each one of us participate in solving the problem and we control our behaviour during the teacher's discussion so we understand from the teacher and our skills improved."
>
> Female student, cooperative group.

> " In the past when I saw numbers I felt that I'm afraid of the problem, now no, I try to solve it and sometimes I can do it."
>
> Female student, cooperative group.

> " Yes, in the last grades the questions used to be direct questions. Now the questions are direct and indirect. For example, drawing the graph gives us half of the solution, understanding the problem gives us a quarter of the solution and the application gives us the second quarter. In groups when we cooperate in drawing the graph of the geometric problem we can take a big step to solve the problem."
>
> Male student, cooperative group.

> " Really I still feel that doing mathematical proofs is very difficult."
>
> Male student, cooperative group.

Although some students in the traditional group (9 out of 24) believe that the teaching method affected their problem solving skills. They considered that this is because, if they could not find the solution, they got the answer from their teachers. However, the other students (15 out of 24) felt that the traditional teaching method did not develop their skills in solving problems because they had no chance to participate in solving problems during the class discussion, or because they could not understand the problem well. One commented that whatever he tried he could not solve the problem because his mathematical knowledge is very weak. Some of these responses are given below.

> " Sometimes yes, I may use the same procedures that other students solve it by on the board. Sometimes I feel that I solve the problem right but I am afraid to make mistakes in front of the students."
>
> Male student, traditional group.

> " Yes, if I could not solve the question I can ask the teacher to solve it."
>
> Male student, traditional group.

> "...With respect to the word problem and difficult ones I cannot solve it and I let the teacher to do it for me."
>
> Male student, traditional group.

> " The word problems, no"
>
> Female student, traditional group.

" No, I think the main reason is related to the difficulty of the material. The material is getting to be more difficult from grade to grade and if the class contains 45 students and if each student wants to ask a question just for one minute the lesson will finish without doing any thing."

Male student, traditional group.

" Solving problems! No, because all of them are in the same pattern and are difficult to be solved".

Female student, traditional group.

" Actually, whatever I tried and in spite of the teacher's discussion I could not solve problems because I'm weak in mathematics and in general in scientific subjects."

Male student, traditional group.

The previous explorations assess how cooperative learning positively affects promoting most problem solving skills. In the view of the students this improvement related to the positive interaction and cooperation that also had been noticed during the group work and the change that had occurred from transferring the situation from teacher-centred into student-centre learning. This atmosphere encouraged and motivated students to challenge the problems and distribute the roles between them in such a way that each of them participate and help others with his/her mathematical understanding to complete and solve the problem. Moreover, students in cooperative learning felt that this method provided them with enough time to discuss, share ideas, explore the solution, evaluate their solution and give them feedback that offers a solution to the weakness they may have and, hence, improves their skills. One important finding is that cooperative learning solved some problems. It broke the feeling of fear or shyness from answering incorrectly in front of the class. Some of them pointed out they might get a more simple explanation from their classmates than from the teacher or they might ask others about mathematical information that was taught in the previous stage while they could not ask the teacher about everything. This is because there is not enough time to answer all of their questions. Students in the cooperative classes felt that the high level of competitive atmosphere noticed gave a chance for most students to participate and motivated them to work hard and to contribute most of the time in the lesson.

Responses from students in the traditional class did not give a good opportunity to explore how the teaching method may affect their mathematical problem solving skills in the group which felt that the teaching method had a positive affect. They explained that this was because of their teacher's skills during the discussion and the teachers' answers to their questions and solving the problems they could not solve. Others commented that this might relate to their good ability in mathematics, because of getting assistance from their parents or by taking mathematical tutorials. Actually, this gave the researcher a clear explanation of the students' responses to some items in the first part of the questionnaire and that they were satisfied and comfortable with their teachers' method because they usually gave them the solutions of the problems they could not solve. The researcher believes that these procedures led to decrease the standard of students in problem solving skills especially in the high level of the objectives and behaviour categories in the cognitive domain, that is the standard of application and analysis, and affect negatively on their ability in solving problems which is opposite to what the students believe. Actually, this gives a good explanation to the contradiction that arises between some students' responses and the decreasing of the level of their ability of standard of application and analysis in the male traditional group. Moreover, the teachers' skills and management of the learning situation and the assistance provided by them explain why the traditional teaching method kept students' mathematical achievement (in standard of knowledge and computation, and comprehension and generally the total achievement) at the same level despite the contents of the material being more difficult than before.

The previous findings explored some issues. For more assessment of the effect of teaching method on students' mathematical achievement and problem-solving skills, the interviews with teachers had been conducted.

Interviews with teachers

The teacher is the person who presents the lessons, discusses the material and evaluates students. So, he/she is the person more than others who can really assess the progress and the improvement which may be noticed in students. Interviews with teachers were conducted at the end of the experiment to explore their judgement about the effects of the teaching method used during the experiment on students' progress in the mathematical achievement and their ability in problem-solving skills.

Teachers' views about students' performance in mathematics and their ability in solving problems

- **Have you noticed the effect of the teaching method on the students' performance? If yes, how? If no, why?**

Investigations with teachers about the effect of teaching method on students' performance illustrated that teachers in the cooperative group highly support the positive affect of applying cooperative learning in their classes. They commented that this teaching method positively affected students' performance in several aspects, such as the cognitive and the affective domains. They found that it was noticeable, without any doubt, that the teaching method affected positively on students' performance. It was noticed that students' scores mostly increased in the quizzes and exams within the experiment especially after applying cooperative learning strategies for a good period of time. Moreover, other improvements had been observed, other than the scores, that are very important to achieve such progress: positive interdependence within the groups; interaction and cooperation; readiness for learning; communication skills; speaking mathematically; social behaviour and, moreover, mathematical skills. Examples of these responses are written below.

> " I noticed that the affect of applying this developmental teaching method in mathematics was clear. The progress and the development were for all students and in a forward way. All students improved and progressed in their mathematical achievement and in their interaction and participation within the class."
>
> Male teacher, cooperative group.

> " Of course without any doubt. The improvement was not only on the standard of scores in the quizzes. Actually, during the group work and the interaction between group mates, students progressed in several fields, like the level of the interaction, interdependence, cooperation, readiness for learning, the communicating skills, the social behaviour and, moreover, the general mathematical skills."
>
> Female teacher, cooperative group.

While all the teachers in the cooperative group mentioned that this teaching method affected positively on the students' performance in several indicators of improvement, within the prescribed time, all teachers in the traditional group commented that no improvement on the students' performance was noticed during the experiment according to their scores in the exams. The students were still at the same level of achievement. They did not refer to other indicators of improvement such as those mentioned from teachers in the cooperative group. One teacher identified the improvement as a physiological maturity, referring to the students' mental maturity and because of the continuous encouragement of the teacher to pay the attention and work hard. Although there was such physiological improvement, no effect of the teaching traditional method was noticed on students' performance than before. He added, it might refer to the difficulty of the mathematical material from year to year or to the students careless. In brief, all teachers agree that the teaching method has no effect on students' performance. This result is supported by the previous quantitative part of the pre-test / post-test students achievement where a positive effect of cooperative learning on students' achievement in all standards and no positive or negative effect of the traditional teaching method on students' achievement except in the male traditional group in the standard of application and analysis. More explanation of this point will be given in the next stage of this part of the qualitative data analysis. Some examples of these responses are written below.

> " No, because the smart student is smart and the sluggish one is sluggish. Every student stayed at the same academic standard."
>
> Female teacher, traditional group.

> " Rarely. If the lesson was a simple one, I may notice a little form of progress in performance within the class. But in general no, their performance was still the same as before."
>
> Male teacher, traditional group.

- **Do you think that the method of teaching participated in promoting problem-solving skill for the students in mathematics? If yes, how? If no, why?**

The second question within this stage was to explore the effects of the teaching method especially on students' mathematical problem solving skills. All the teachers in the cooperative group highly supported the positive effect of cooperative learning strategies on promoting the problem solving skills of the majority of the students. They illustrated that this teaching method encouraged and motivated students through the group work to interact, cooperate and participate in solving the problems. They added that it changed the learning situation 180 degrees from a teacher-centred situation into student-centred learning that affected positively day after day in promoting different mathematical skills, such as reading and writing, computation, drawing mathematical diagrams and geometric figures, speaking mathematically and using mathematical vocabulary, translating word problems into mathematical ones, understanding the problem, choosing the correct procedures and algorithms for solving the problem and evaluating their solutions. At the same time, two teachers commented that this teaching method could not improve students' ability to do mathematical proofs. It was noticed that group-mates still found many difficulties to teach and help others in how to do the mathematical proofs. Moreover, they mentioned that cooperative learning creates a good opportunity for the students to do mathematics by themselves, to think and to challenge the problem to solve it. Such behaviour had not been observed previously. The following examples indicate some of the teachers' answers.

> " Yes, because the student within his group can solve the mathematical problem as a group of students. And if he did not understand from the teacher, he could understand through the group discussion. This situation does not exist in the traditional method where the student may understand or not. This gave the student more than one chance to understand and hence this method improved his ability to use the concepts, the rules and the suitable algorithms in solving problems."
>
> Male teacher, cooperative group.

> " Yes I noticed that with high level in drawing geometric figures and diagrams, following the steps in solving the problem starting by reading the problem, determining the given information, the request from the question, planning for solving, using algorithms and so on... the continuous series in solving the mathematical problem. But no real improvement was noticed in the ability to deal with mathematical proof."
>
> Female teacher, cooperative group.

All traditional teachers highlighted the difficulty of this standard of mathematical construction and the students' weakness to deal with mathematical application and problem solving skills. Some of them mentioned that a limited number of students progressed. They referred to the students' mental maturity or to the encouragement they gave to students to assist them in understanding the problem and simplifying it in order to help them in solving the problems. All of them agreed that most of the students did not progress in problem solving skills. They gave several reasons, such as students lack of concern, the quantitative momentum of the material, the crowded classes, the pressure of the time to cover all the material in a specific time, the inability to contact all the students in the class individually to evaluate them and offer a solution to their weakness and, finally, because of students' previous background and their weakness in problem solving. Some examples of teachers' responses to this part of the investigations highlighted through the interviews are given below.

> " Yes and no, yes for the number of students because of their mental maturity and no for most students because of their lack of concern, because of the quantitative momentum of the material and because of the crowded classes that are handicapping to reach to all the students individually."
>
> Male teacher, traditional group.

> " No, I did not find any changes unless they depend on the teacher's assistance in simplifying, for example, a word problem."
>
> Female teacher, traditional group.

> " Actually a little bit. The basic skills in problem solving were usually identified as application problems and we observe that often when the student read such problems he did not understand them at all. For example, today I asked a student to give me the converse of the middle digit from the double of the number it self. The student did not understand it at all. They really have a weak ability in basic computational skills. If I asked what is the double of 2/5, they said 4/10 and so on... This weakness related to several reasons and also in solving the problems of linear and quadratic equations. Students found many difficulties in analysing the problem, collecting the information and using the algorithms to solve it correctly. This is because of many reasons. One of them is that students are not used to dealing with such standards of problems in the past; they are used to solving simple and direct questions and are not used to transferring the learning into new situations and applications. Although I concentrate on solving such standard of problems I face many difficulties to increase the students' levels in such applications."
>
> Male teacher, traditional group.

- **Can you describe the atmosphere you feel in your class during the teaching and learning process? Do you think that this atmosphere may help the progress of the learning process in mathematics?**

The interviews conducted with teachers for this part search for more description about the class atmosphere, how the teacher felt during the teaching and learning process and if such atmosphere helps to develop the learning process in mathematics.

Teachers had different feelings in their classes. The cooperative teachers felt that it takes much effort to prepare the lesson for the group work and to organise some activities and worksheets and that is because of the poor resources available to them to apply such a teaching method effectively; moreover, the large number of students and the suitable furniture to organise the classroom physically and to collect tables for the group work created some difficulties. However, in spite of the efforts they made, they felt that the atmosphere was charged by interesting activity, fun, efficiency and cooperation. Moreover, they felt happy because of the instantaneous fruits they gain. All of the cooperative teachers commented that this atmosphere positively affects the learning process. Some examples of these responses are quoted below.

> " In spite of the efforts we made in preparing for the lesson and organising the classroom for the group work, I felt the atmosphere was full of fun, interest, activity and motivation to let all the students participate within the group work."
>
> Male teacher, cooperative group.

> " The atmosphere was always charged by the cooperation and interaction between students within their groups and by the competition between the groups within the class which creates a wonderful environment for teaching and learning."
>
> Female teacher, cooperative group.

> " The atmosphere was very interesting and in some mathematical subjects I was waiting impatiently to enter the class."
>
> Male teacher, cooperative group.

The responses of teachers in the traditional group were different from one another, but all of them commented that the atmosphere had no real effect on improving the learning process. Some of the teachers felt bored because the interaction was not at high level, others felt pressured by the large number of students and the limited time to cover the material, and others felt confident because they were satisfied with their teaching. All the teachers said they felt disappointment at the end of the lesson when they asked students to solve some problems because they usually found that only a limited number of students could solve the problems and the rest of the students did not do any thing or sometimes they would copy the answers from other classmates without any understanding. Some of these responses are given below.

> " Its ok, but sometimes I feel pressured especially in the summer because the class contains a large number of students and we shall cover all the material in a limited time. This atmosphere actually affects negatively on the students and on the teacher. Sometimes I may forget something I wanted to discuss with them and sometimes I may do something to break the routine and the weariness by doing some competitions. However, this atmosphere does not develop the learning process and does not play much of the role in this issue."
>
> Female teacher, traditional group.

> " I feel, thank God, comfortable and confident during the discussion. I feel disappointed when low achieving students make no progress or any response to me or, in general for most students, because of their carelessness especially if they were busy with other things during the discussion."
>
> Male teacher, traditional group.

- **Does the teaching method offer a solution for some students who have disabilities or those who are low achievers a chance to help them succeed?**

All teachers in the cooperative group agreed that cooperative learning cures some difficulties in learning in different aspects, either cognitively for low achieving students, or behaviourally for students who feel fear, shame, impetuosity, or rashness or even physiologically, for those who have a weakness in seeing or listening. Moreover, they commented that it gave a chance for low achieving students, academically, even if only slightly, but something is better than nothing. The following quotations present examples of these responses.

> "Yes, for some students, usually we don't have disabilities in our classes. But this method gave low achieving students a chance to promote their skills, not necessarily in mathematical subject only but in general it may increase his computational skills, reading skills or writing skills."
>
> Male teacher, cooperative group.

> " Yes it cures some difficulties in learning for some students like shame, academic weakness, impetuosity and rashness. I noticed that one student who used to be absent from most lessons became very eager to attend the class and when I asked him about this change he answered that it is because of the interest he found in working cooperatively in mathematics with his group mates."
>
> Male teacher, cooperative group.

> " Yes, for example if a girl cannot see or hear me when writing on the board, she may hear well or see better while she works with her group mates. For low achieving students, yes, it gives them a chance

> to succeed even if they get little benefit, but something is better than nothing."
>
> Female teacher, cooperative group.

The responses of the traditional teachers to this part about the opportunity for students who have a disability in learning or even low achieving students to cure their difficulties, all showed agreement that the traditional teaching method could not solve their problems. Teachers commented that using the traditional teaching method could not cure students' weakness in mathematics because this would waste the time. Moreover, this teaching method could not offer a solution to students' carelessness. The responses of the traditional teachers concentrated on the academic domain. None of them paid any attention to other disabilities like those in the cooperative group, except one teacher, who commented that those students need special classes. Some of these responses are given below.

> " Actually no, maybe for middle achieving students but not for low because this will waste time. "
>
> Female teacher, traditional group.

> " No, and that is because of the carelessness of those students and moreover, the existence of a lot of difficulties in learning for them. However, I always tried by repeating the information and giving a lot of quizzes to encourage them to study because they were not used to studing unless for exams."
>
> Male teacher, traditional group.

> " No, because it does not help low achieving students."
>
> Female teacher, traditional group.

> " Actually for students who have disabilities there are special classes because they need specialists in that field. For low achieving students when a student came in year nine and he does not know any thing and is very weak in mathematics I think it is very difficult to cure his difficulties."
>
> Male teacher, traditional group.

- **Do you notice that the students' progress and improvement depend on their achievement? Alternatively, does the method affect differently according to their academic ability?**

With respect to the effect of the teaching method on students' mathematical performance according to their academic ability, teachers in the cooperative learning classes commented that all middle and low achieving students made progress in different aspects of mathematical performance, as was discussed previously. Moreover, they commented that this progress was noticed as a result of applying cooperative learning in mathematics within the period of the experiment, even if it was a small amount, for the very low achieving students but they added that something is better than nothing. With respect to high achieving students in the cooperative group, all teachers commented that the teaching method has no real effect on those students because they are, from the beginning, very good at mathematics. They referred to the effect of their home and their parents care for their children's achievement. One male teacher in the cooperative group commented that he felt that cooperative learning creates a kind of frustration for some high achieving students because they spend the time in helping others who may take the leading position from them if they made more progress. Other teachers said that one day an excellent student let a tear escape from his eyes because he missed the leading role in his group that week. Some of teachers' quotations are written below.

> " I noticed the progress in all levels. Middle achieving student become good ones, low achieving students become better but still had weakness in mathematics because of other accumulated social and home factors that effect them and the teaching method alone cannot help in solving these problems."
>
> Male teachers, cooperative group.

> " It affected all of them in spite of their academic achievement and that is because of applying the cooperative method. But I felt that a high achieving student was frustrated because he spent time helping other one which may take from him the leading position. However, this method had no real effect on high achieving students because I think the real effect comes from their homes."
>
> Male teacher cooperative group.

> " Actually, there were some girls who were very weak but when we used a good teaching method they would interact and gain progress even if they were very weak."
>
> Female teacher, cooperative group.

All traditional teachers mentioned that the teaching method had an effect on the students according to their level of achievement but no changes have been observed in their mathematical ability and all of the students stayed at nearly the same level. One male teacher commented that he found that some low achieving students decreased more in their scores and performance which is related to many factors where the traditional teaching method could not solve their problems. Some of these responses are mentioned below.

> " I noticed that most of them still at the same level nearly."
>
> Female teacher, traditional group.

> " Actually, the good one is good and the weak one is weak."
>
> Male teacher, traditional group.

> " I found that the teaching method affects according to their level of achievement: high achieving girls asked hard questions and were pleased to answer difficult ones and solve other questions from outside the textbook. Middle achieving girls solved the same examples from the textbook and low achieving girls did not take care with any thing."
>
> Female teacher, traditional group.

> " I think that high and middle achieving boys stayed in the same as their previous level but low achieving students got worse year after year and that is because of their carelessness and additional to that, the material gets more difficult from year to year and the traditional teaching method could not help to solve their problems and motivate them for learning."

Actually, when the researcher asked that teacher if he meant that cooperative learning may be the solution, the teacher answered:

> "Yes, I think so".
>
> Male teacher, traditional class.

Summary of previous findings

The previous findings of the study illustrated that cooperative learning positively affected students' mathematical achievement and problem solving skills. The progress of the students was noticed in different aspects, such as mathematical achievement and scores, communication skills, interaction, cooperation, positive interdependence, reading and writing skills, computational skills and, moreover, mathematical problem-solving skills. This positive effect was related to the new shift which had occurred in the teaching and learning process in the cooperative classes from the teacher-centred situation to student-centred learning that motivated and encouraged all students to interact, cooperate and participate in solving problems. This teaching method gave most of them a chance to do mathematics by themselves without depending on their teacher for giving them the answers and the solutions for the question unless none of the group members could solve the problems.

Cooperative learning created a cognitive atmosphere that enabled the students to gain benefits from each other by sharing ideas, introducing several solutions, evaluating their solutions and providing feedback in an interesting and exiting way.

While a positive effect was found by applying cooperative learning strategies in the mathematics classroom no affect had been noticed or measured in the students' mathematical outcome. Most students stayed at nearly the same level. In spite of students' beliefs that the teachers' discussion positively affects their mathematical performance in the traditional classes, the teachers commented that there was no progress in their mathematical abilities. They gave more explanation and referred to many factors, such as students' initial ability and their mathematical background, the effect of their social class and families' culture, the difficulty of the material and students' carelessness. The most important thing is that the traditional teaching methods used in their classes did not cure those problems because of the crowded classes and the pressure of time to cover all the material of the curriculum within a specific period. Moreover, because the atmosphere within the class gave no chance for most students to participate and interact in solving the problems, it was noticed that the students in the traditional classes depend most of the time on their teachers to introduce the lesson and give most of the answers without giving enough opportunity for students to do mathematics by themselves.

With respect to students' responses in the cooperative group, there was more agreement to the quantitative findings where the teaching method affected promoting their skills in mathematical problems but it did not extend to mastering such skills efficiently. This also supports the research findings. While there was noticeable progress with statistically significant differences in students' mathematical achievement and problem solving skills before and after the experiment in the cooperative method, there was still a weakness in students' mathematical ability, especially in the standard of application and analysis, in the two experimental groups that were considered an the high level of thinking.

The students' response in the traditional group, especially the male group did not support the quantitative findings in the pre-test / post-test assessment. This is especially in some items that related to the standard of application and analysis in the high level of thinking. While their responses in some items were more in agreement of the positive effect of the traditional teaching method, the real scores and achievement in the pre-test / post-test assessment and their teachers' beliefs about their mathematical achievement does not support their responses.

However, the students' and teachers' responses hardly support the quantitative findings in the two experimental groups. While the average of the students' response agree that there is a positive effect for cooperative learning on promoting students' mathematical achievement and problem solving skills, the average of students' response in the traditional group was uncertain of the positive or negative effect of the traditional teaching method. This supports the findings of the pre-test / post-test assessment except in the standard of application and analysis in the male traditional group where the negative effect was found.

8.2 Second Issue: Analysis of the views of students on the use of cooperative learning versus the traditional teaching method in the teaching of mathematics

Assessment of students' perspectives and views towards teaching strategies and teachers' ability to use them

One basic issue in this present study is to analyse the views of students on the use of cooperative learning versus the traditional teaching method in the teaching of mathematics. Within this stage the researcher:

- assesses students' views about the rationality for using cooperative learning versus the traditional teaching method
- investigates students' perspectives about some teaching skills and the ability of their teachers to use these skills
- explores students' views about the advantages and disadvantages of the use of cooperative learning versus the traditional one.

The quantitative and qualitative data were collected by sending questionnaires to all students involved in the experiment and conducting interviews with a random sample of students for use at the analytical stage. The following discussion of the quantitative and qualitative stage analyses the views of students on the use of teaching methods and answers the questions on this issue for the research study.

- **The quantitative part**

<u>**The questionnaire (part two)**</u>

This instrument was used for the quantitative part of this issue (see appendix three, part two) to assess students' views and perspectives towards teaching strategies. Means and standard deviation for this part of the questionnaire were calculated previously (see table 8. 10).

Since there were differences in the means and the standard deviations, multivariate analysis of variance (MANOVA) was used to assess if there were statistically significant differences in the students' responses towards this part of the questionnaire (as a dependent variable) related to the effect of teaching method, gender and the interaction between teaching method and gender (as independent variables) (see table 8.11).

Remark: for the effect of the interaction between teaching method and gender see appendix nine (b).

Table 8.11 (with respect to part two of the questionnaire) reveals that:

1. There are statistically significant differences in the students' response relating to the method of teaching. Hence:
    - Hypothesis 13. H0 is rejected.
    - Hypothesis 13. H1 is accepted.

<u>Remark</u>: for hypothesis 13.H0 and 13. H1 see page 142.

Comparing means in table (8.10) indicated that the mean of the total cooperative group was more than the mean of the total traditional group (3.5872 > 3.1657) with statistically significant differences. This means that those students' views on the use of cooperative learning were more positive than those in the traditional classes. In addition, it reveals that the students in the cooperative group were mostly agreed and satisfied with the use of cooperative learning strategies, while the students in the traditional group were mostly uncertain of their perspectives and views about traditional teaching strategies and did not give definite response for this part of the questionnaire.

2. There were no statistically significant differences related to gender (Sig. 0.110 > 0.05).

That means that there were no gender differences in the students' views in the female and male groups regarding the method of teaching. Hence:

- Hypothesis 14. H0 is accepted.
- Hypothesis 14. H1 is rejected.

<u>Remark:</u> for hypothesis 14.H0 and 14.H1 see page 142.

3. There are statistically significant differences in students' response towards this part of the questionnaire related to the interaction between teaching method and gender (see appendix nine (b)). Hence:
   - Hypothesis 15. H0 is rejected.
   - Hypothesis 15. H1 is accepted.

<u>Remark:</u> for hypothesis 14.H0 and 14.H1 see page 143.

Comparing means in table 8.10 shows these differences. While the mean of the female and male cooperative groups is nearly the same (3.5930 and 3.5814 respectively), the mean of the traditional male group is more than the mean of the traditional female group. This means that students in the male traditional group were more satisfied with, and interested in, the teaching strategies than the female traditional group and their response is more positive towards the teaching strategies involved in their classes. Moreover, female and male cooperative groups are more satisfied and in agreement than those in the traditional classes for the use of cooperative learning versus the traditional strategies and were more satisfied with their teachers' teaching skills. This can be explained by the professional development that has occurred for the teachers during the training programme and during the implementation of applying the new strategies in the cooperative mathematics classes. Actually, this issue cannot be ignored within the analytical stage where teachers in cooperative classes were more motivated and enthusiastic towards applying the new method of teaching in an effective way.

Another important finding to be highlighted here is that students in the traditional male classes were more satisfied with their teachers' skills and agreed more with applying the traditional strategies than the female traditional group. This can be explained by their satisfaction with their skills in teaching mathematics, the relationship between them and their teachers and the teaching and learning situation in their mathematical classes which was more than those in the female traditional classes. Actually, this finding is so sensitive and discusses more results that will be raised during the next stages of analysis.

The previous statistical techniques represent initial evaluation. So, for more explanation, frequencies and percentages for the items in part two of the questionnaire were calculated and, accordingly, students' responses towards the items were analysed (see table 8.13). This in order to:

- give more judgement about students' views towards teaching strategies involved in their classes
- examine to what extent they were satisfied with teaching strategies involved in their classes and willing to use them.

Table 8.13
Frequencies and percentages of the students' response (agreement, uncertainty and disagreement) towards the items in part 2 of the questionnaire

Part two: Students perspectives toward teaching strategies

Item	TM	G	Agreement		Uncertainty		Disagreement	
			Frq.	Per.%	Frq.	Per.%	Frq.	Per.%
1. I'd like to continue using the same teaching method in mathematics.	C	F	54	62.79	22	25.58	10	11.63
		M	60	69.77	6	6.98	20	23.26
	T	F	67	74.44	5	5.56	18	20.00
		M	47	55.29	13	15.29	25	29.41
2. I prefer to use the mathematical teaching method in other subjects.	C	F	62	72.09	10	11.63	14	16.28
		M	55	63.95	10	11.63	21	24.42
	T	F	39	43.33	10	11.11	41	45.56
		M	32	37.65	24	28.24	29	34.12
3. The subjects in mathematics are introduced in an interesting way.	C	F	55	63.95	16	18.60	15	17.44
		M	67	77.91	13	15.12	6	6.98
	T	F	42	46.67	10	11.11	38	42.22
		M	43	50.59	10	11.76	32	37.65
4. Teaching method creates a competitive atmosphere.	C	F	68	79.07	10	11.63	8	9.30
		M	56	65.12	10	11.63	20	23.26
	T	F	44	49.44	18	20.22	27	30.34
		M	42	49.41	11	12.94	32	37.65
5. I prefer to ask about some ideas in mathematics from my classmates.	C	F	72	83.72	7	8.14	7	8.14
		M	44	51.16	15	17.44	27	31.40
	T	F	44	50.00	9	10.23	35	39.77
		M	35	41.18	10	11.76	40	47.06
6. Some of the classmates can explain some points in an easier way than the teacher can.	C	F	38	44.19	17	19.77	31	36.05
		M	21	24.42	13	15.12	52	60.47
	T	F	31	35.23	13	14.77	44	50.00
		M	30	35.29	11	12.94	44	51.76
7. I do not hesitate to ask the teacher about any problem I may face in solving problems.	C	F	60	69.77	16	18.60	10	11.63
		M	68	79.07	7	8.14	11	12.79
	T	F	60	67.42	10	11.24	19	21.35
		M	54	63.53	10	11.76	21	24.71
8. The teacher can answer all the students' questions within the class.	C	F	63	73.26	9	10.47	14	16.28
		M	69	80.23	4	4.65	13	15.12
	T	F	34	37.78	9	10.00	47	52.22
		M	56	65.88	5	5.88	24	28.24
9. There are no major differences in mathematics teaching strategies.	C	F	2	2.33	6	6.98	78	90.70
		M	10	11.63	10	11.63	66	76.74
	T	F	67	75.28	5	5.62	17	19.10
		M	65	76.47	8	9.41	12	14.12
10. The teacher links mathematical problems with the different life situations and their applications.	C	F	33	38.37	13	15.12	40	46.51
		M	49	57.65	13	15.29	23	27.06
	T	F	33	36.67	13	14.44	44	48.89
		M	41	48.24	16	18.82	28	32.94

TM: Teaching method.
G: Gender.
C: Cooperative.
T: Traditional.
F: Female.
M:Male.

Table 8.13 shows the frequencies and percentages of the students' response to the items of this part. The items search for students' views about the teaching strategies involved in their classes and their interest in using them in their classes. Some items explore some teaching skills and others search for the students' role within the class. Students' response indicates that:

1. Items 1, 2, 3 and 4 show that most students in all groups are satisfied with the continuity of using the same teaching strategies in their mathematics classes. It seems in item 1 that female students in the traditional group agree more to continue using the same method than those in the cooperative group, while the opposite in the case in the male groups. This may relate to students' ability, where the traditional group contains more high achieving students, those who prefer the competitive atmosphere rather than the cooperative one, as will be discussed in detail in the next stages of the analysis. Students in the two female and male cooperative learning groups were more interested and willing to use cooperative strategies in other subjects than those in the traditional classes. This may be reflected as a result of their interest in working cooperatively and using the new teaching method which creates a competitive atmosphere between groups within the mathematics class and enables most students to participate. This point will be highlighted in the next qualitative stage of this part of the study.
2. Item 5 and 6 show that those students in the cooperative group agree more than those in the traditional classes to ask for assistance from their classmates in some mathematics ideas, especially the female students. In spite of that response most students in the two groups disagree that their classmates may be able to simplify some mathematical knowledge than the teacher can except the female cooperative group those who mostly prefer to ask their classmates and most agree that they may help them more than the teacher can. This may relate to the high level of the interaction and cooperation applied, especially in the female cooperative groups, that will be discussed later on.
3. Items 7 and 8 show that most students in the cooperative and traditional groups do not hesitate to ask their teachers for assistance in problem-solving but those students in the cooperative groups agree more than those in the traditional classes that the teacher can answer all the students' questions in the class. This is a good response that arises although students are mostly satisfied with their

teachers' ability to answer their questions and their attempt to ask their questions but the situation in the traditional classes gave no chance for the teacher to answer all questions and explains how teachers in the traditional classes cannot deal with all students together, especially in such crowded classes, while the cooperative group mostly agreed that the teachers have a good opportunity to answer their questions. This may be because it is easier for the teacher to deal with 6 or 7 groups within the class while it is so difficult for them to deal with all 42 students or, sometimes, more than that. In addition, a detailed exploration for these issues will be highlighted within the qualitative stage of the analysis.

4. Items 9 shows how different the views were of the students were in the teaching strategies involved in cooperative classes compared with the traditional ones where previous items (items 1,2 and 3) present their interest and satisfaction when these changes occurred. Moreover, these results did not indicate that students in the traditional group were not satisfied with the teaching methods involved in their classes. These views also support previous findings that teachers in the traditional group, and their teaching skills, satisfied their students.
5. Item 10 shows that teachers in the two experimental groups did not link the mathematical problems with the daily life situations especially in the female groups. One important issue in the Jordanian mathematics classroom is that mathematics is, until now considered and has been taught as, an abstract subject without real concern for its applications, especially in our daily life situations. This may be related to many reasons, especially in the mathematics curriculum. In addition, this point will be addressed in the next stage of the analysis and discussion. However, this may answer a very important question which is, Why do students have a weak ability in problem-solving skills?

Summary of previous quantitative findings in part two of the questionnaire

The previous findings indicate that all students in the two experimental groups were satisfied with the teaching strategies and their teachers' skills involved in their classes. Nevertheless, students in the cooperative classes were more satisfied and interested in their classes. They looked forward to applying the strategy in other subjects and they felt that this method was introduced in an interesting way that created a competitive atmosphere. Most students see that their teachers are more enabled to simplify their problems in doing mathematics and they did not hesitate to ask their teachers for assistance. However, students in the cooperative classes can find more opportunity to be answered by their teachers than those in the traditional classes. The female cooperative group believes that their classmates may offer them good assistance which may reflect the high level of cooperation and interaction which occurred especially in the female groups and supported the high progress assessed in the previous analytical stages.

The Qualitative Part

Interviews with students

The previous quantitative analysis indicated that, although most students in the two experimental groups were satisfied with the teaching method applied in their classes and their teachers' ability to use it in teaching mathematics, students in the cooperative group had more satisfaction and agreement towards this new teaching method. However, the following data analysis for the qualitative part in this stage explores and analyses the views of students on the use of cooperative learning versus the traditional teaching method in the teaching of mathematics. Three basic headlines will be investigated of the view of students within this stage. The following qualitative data analysis will answer the research questions for this part of the study.

Students' views about the teaching method and the rationality for using it

- **Are you satisfied and comfortable with the teaching method in mathematics? Why?**
- **Would you prefer to continue using this method or return to the previous method / change the method of teaching?**

Most students in the cooperative learning classes were satisfied and comfortable in applying cooperative learning in their classes (19 out of 24). They commented that they were satisfied with their teachers' discussion and they felt comfortable to apply the teaching method because it helped them to improve their skills in solving mathematical problems. Moreover, it gave them a chance to depend on themselves in doing mathematics.

> "In my opinion this was the first time I felt that I could do mathematics by myself and I can find people who help me. The very important thing is that in the past the teacher could not evaluate our solutions so if we made some mistakes we could not find any one to guide us how to solve the problems but in the group work we know what mistakes we have made and correct them without any feeling of fear or shyness in front of the class. So, we feel comfortable in solving the problems."
>
> Female student, cooperative group.

This comment showed one of the student's beliefs about how the new learning situation gave him more chance to practice the mathematical skills by himself and to get assistance when needed from his group mates. Moreover, this situation allows opportunities for students to assess their solutions, to discover mistakes and correct them through working in groups without any feeling of fear or shyness; thus, students are motivated to do mathematics.

The class became a community of students learning in an interesting and exciting way. Some students commented that it is very rational to apply this teaching method because it also gives chance for the teacher to follow all the students within the group, evaluate their solutions and help them in an comfortable way if all of them need help. All those students added that they would prefer to continue using this teaching method and some of them would like to apply it in other subjects. Some of these responses are given below.

> "Really, the teacher is wonderful in introducing the material and I felt very comfortable using the cooperative method because I could deal with my group in an interesting and exciting way. ...Yes, I'd like to continue."
>
> Male student, cooperative group.

> " Yes I'm satisfied with my teacher's discussion and I feel comfortable because this teaching method gave me a chance to ask my group-mates about anything I did not understand from the teacher and so, I think it developed of my problem solving skills.... Yes, use the same teaching method. "
>
> Female student, cooperative group.

Few students (5 out of 24) had different feelings toward this teaching method. One girl who was a high achieving student said:

> " I do not take care which method is used because it makes no difference for me. I'm a good girl in mathematics and it is the same for me if they apply the cooperative or the traditional teaching method".
>
> Female student, cooperative group.

high achieving boy said:

> "Actually, I did not feel comfortable although I was satisfied with my teacher's ability to apply cooperative learning because I felt that I spent a lot of time helping other students in my group and because the leader of the group is not fixed. Some one may take the leader's role from me and when that happened I felt very sad".
>
> Male student, cooperative group.

Another three students commented that although they were interested and satisfied to apply this teaching method they felt that it took a lot of effort and wasted time in re-arranging the desks before the lesson and returning them after the lesson. This made some noise, especially in the crowded classes. One student commented that:

> " You may find an impudent boy who tries to disturb the group work. This meant other group-mates felt disturbance and noise."
>
> Male student, Cooperative group.

Another male student commented that:

> " Of course I'm satisfied because this teaching method has a lot of advantages but on the other hand this method needs a lot of efforts in arranging the desks for the need of the group-work which made a noise in the class. I would prefer to continue but I hope there is suitable furniture in the class. "
>
> Male student, cooperative group.

Those responses illustrated that cooperative learning strategies may have no effect or, sometimes, may have negative effect on high achieving students because their achievement is not related to which teaching method is applied in their classes. Moreover, this teaching method might not give them the same chance, as in the traditional classes, to shine themselves in front of their teachers and their classmates.

Actually, the previously identified problems were not so prevalent in all classes involved. In the two female classes none of these issues had been observed and the girls were very helpful in arranging the classroom. It was noticed by the researcher, within the lesson observations, that the classes were well organised from the beginning of the lesson and the teachers did not complain of anything relating to organising the classroom physically. In the male group one teacher preferred to use groups of four to facilitate this problem in which every two students would turn their desks around which was a good idea. This problem arose in one male class but, after a period of time, it was solved.

Students in the traditional group had different feelings. Some of them felt comfortable because they could understand the material from the teacher or because they could participate in the class if they wanted to. In addition, it was observed that these responses were from high achieving students.

> " I can understand the teachers' discussion and that's what I want. "
>
> Male student, traditional group.

> " Yes, because if I raise my hand to answer, the teacher may ask me to solve on the board and hence she will know me that I'm a good girl."
>
> Female student, traditional group.

Most other students commented that, although they were satisfied with their teachers' discussion, they did not feel comfortable because either they felt afraid to answer in front of the class, or because they felt that they did not have any role in the lessons; they had no chance to participate, the teacher could not help them because of the large number of students in the class and because, sometimes, their minds would wander away from the lesson because there was nothing to encourage them to pay attention to the lessons.

> " No, because I felt that I hadn't any role in the class and I had no chance to participate."
>
> Male student, traditional group.

> " The discussion was good. But sometimes, my mind might wander because there was nothing interesting to be attention to it."
>
> Female student, traditional group.

Assessment of students' views of their teachers' ability to use the teaching methods

- **Do you think that your teacher applies the mathematics teaching method in a good way?**
- **Should your teacher continue using the teaching method or return to the previous method/ apply a new method of teaching?**

All students in the two experimental groups believed that their teachers applied the mathematics teaching method in a good way because they discussed the material well and, if any student asked a question, they answered. Students in the cooperative group commented that their teachers should continue the teaching method because of its advantages and because they were able to apply it in an affective way. Some of them hoped that their teachers would help other teachers at school to apply cooperative learning in other subjects.

> " Yes, his teaching was wonderful ...continue because it is useful for all of us."
>
> Male student, cooperative group.

> " Actually my teacher's discussion is very nice and I felt that she applied the cooperative method in a wonderful way. Yes, she should continue."
>
> Female student, cooperative group.

> " Yes and I hope he will help other teachers to apply it in other subjects."
>
> Female student, cooperative group.

Most students in the traditional group commented that their teachers could continue the existing teaching method but that it was better to apply a new one. High achieving students recommended that teachers should continue this teaching method because it offers the teacher an opportunity to control the class without any disturbance and to cover all the material. Moreover, the students have a chance to participate within the class.

> " Yes, his teaching is wonderful and he can pass the information to us... he should continue."
>
> Male student, traditional group.

> " Yes, he should continue because this method enables him to control the class well without any disturbance. "
>
> Male student, traditional group.

> " Without any doubt, the teacher's discussion is good. We understand and participate in solutions... continue."
>
> Female student, traditional group.

Other intermediate and low achieving students hoped that their teachers would try a new teaching method, like the cooperative teaching method, because they had heard about it from their friends in other classes and they felt that it may solve many of their problems by giving them a chance to get their friends' assistance in doing mathematics in an interesting way. Also, it may give them a chance to participate because, in the traditional method, the teacher has not enough time to follow all of them and assess their solutions and they have no role in participating in the class because the students who raise their hands quickly are those who always participate in most lessons.

> " The teacher's discussion is good but he can not follow all of us to observe and evaluate our solutions. We hope he will try cooperative learning. We heard about it from our friends and it was helpful for them."
>
> Male student, traditional group.

> " I cannot say that his teaching is not good. But I'm weak in mathematics and this teaching method did not help me to treat my weakness. I hope the teacher will try other teaching methods."
>
> Male student, traditional group.

> " Yes she is. She could continue but I would prefer it if she applied more interesting teaching methods like other classes. Actually, we felt bored in the class and that is because we did not have any role at all. If we didn't understand well, we could not find any one to help us or to correct our mistakes. Actually, the teacher just deals with the same students who usually work with the teacher and the rest of the class just listen and cope. "
>
> Female student, traditional group.

Previous comments also indicate that, in the views of students, traditional classes give no chance for low achieving students to participate which makes them feel bored. On the other hand, this situation does not allow them the opportunities to get help for their difficulties where the teacher has not enough time to assess their solutions and correct their mistakes while the cooperative situation could offer such treatment.

Advantages and disadvantages of the teaching method

- **What are the advantages and disadvantages of this teaching method?**

The advantages and disadvantages of the two experimental teaching methods (cooperative and traditional) had been explored during the interviews of the views in students as well as teachers. This will be presented in detail in the next stage.

Figures 8.1 and 8.2 summarise the advantages and disadvantages of the teaching methods in the views of students and teachers. The following responses are some examples of students' beliefs in the two experimental groups.

> " The advantages are: the cooperation between group-mates, improvement in some students' level of achievement especially low ones and all students have a chance to participate.... No disadvantages. "
>
> Female student, cooperative group.

> " I found that the cooperative method was useful because I can understand more than before, I have a role in participation, I can present my solution and if it is wrong and if I do not understand a point from the teacher I can ask my group-mates. But I think it needs more time. "
>
> Male student, cooperative group.

> " This method encouraged me to do mathematics by myself and I became less dependent on the teacher most of the time like before."
>
> Female student, cooperative group.

> " The method was interesting and helpful but some students might cause disturbance within their groups."
>
> Male student, cooperative group.

> " I feel in this method that the teacher is a sender most of the time and the student is a receiver to stuff the students' mind with information."
>
> Male student, traditional group.

> "Oh, really nothing new. I feel bored and we just copy what the teacher writes."
>
> Female student, traditional group.

> " Although the class was always quiet and well organised I felt that the participation was nearly absent unless for the same few students. Some times I felt sleepy during the lesson."
>
> Male student, traditional group.

> " Actually this method gives high achieving students the chance to raise themselves and learn then the selfishness appeared in these students. Hence, there was no participation or competition except for them."
>
> Female student, traditional group.

> " Every one is responsible for himself."
>
> Male student, traditional group.

The previous examples do not include all students' views about the advantages and the disadvantages of the two teaching methods. Figures 8.1 and 8.2 present a thorough discussion.

Summary of findings

The quantitative and qualitative data analysis indicates that students in the two experimental groups were satisfied with their teachers' ability in discussion but students in the cooperative group were more pleased and satisfied with conducting the new teaching method because of the advantages they found. Students in the cooperative learning group felt that it was rational to apply the method because it gave them a chance to participate and interact with their group-mates in solving problems. Moreover, the cooperation offered the opportunities for them to help each other and get benefits. Therefore, they felt that it improved their skills in mathematics. While some traditional students were satisfied and comfortable in applying this method (high achieving students), other students (intermediate and low achieving students) felt that it did not help them to cure their weakness or to give them any chance to participate. Even more, it did not give their teachers a chance to assess them. Most students in the cooperative group would like to continue using this method because of its outcomes, except some high achieving students who felt that they spent their time in helping others. Moreover, they might miss the leading role in their groups and, hence, that might cause some kind of frustration for them. Some students in the traditional classes hoped that they could apply the cooperative method because had they heard about it from their friends in other classes and they felt that it was helpful for them.

The advantages and disadvantages of the two teaching methods in the views of students and teachers are summarised in figures 8.1 and 8.2. This to present them in a clear way and to give the reader a wide look at how cooperative learning was more rational to be applied in the mathematics classroom.

8.3 Third Issue: Analysis of the views of teachers about the use of cooperative learning strategies versus traditional ones

Teaching and learning processes and the relationship between them is a complex issue. Many factors come together to form the students' outcomes. One basic factor in this process is the teaching method that is applied within the classroom to achieve the general objectives of the teaching of mathematics as well as the specific objectives of the mathematics lessons. The teacher is the key person in the teaching and learning situation responsible for introducing the lesson, providing information, giving examples, explaining concepts or skills, evaluating students and giving them feed back. Moreover, no one can evaluate and assess the learning process in the classroom situation and when, how and why to use different teaching methods more than the teacher because he/she is the one who know all the elements in the class that are combined to achieve the students' outcomes.

Teaching methods and the strategies applied by the teacher during the implementation of the mathematics lessons include all the tools and procedures they follow to achieve the general and the specific aims of the mathematics lessons. These enable the students to use the mathematical knowledge that has been previously learned and stored in the memory to learn new mathematical subjects, to gain new information and skills and to use it in new situation. Moreover, teachers always aim to evaluate the learning process and the students' outcomes and to assess to what extent the objectives of the mathematical lesson were achieved.

Actually, the teaching method is the bridge that links teacher and students in all aspects of the learning and teaching process. The successful teacher is the one who chooses the suitable methods and strategies to match the classroom-learning situation to achieve his/her goals effectively.

The following interviews with all teachers involved in the experiment investigate the teachers' views about the use of cooperative learning versus the traditional one in the mathematics classroom. Several outlines were considered within these interviews. These include teachers' beliefs about the effect of the teaching method on the learning process, the rationality for using the applied teaching method, teachers' attitudes towards the teaching methods, the teachers' views of the students' assessment of teaching method and, finally, the advantages and disadvantages of the teaching methods involved within the experiment. The following discussion explores the views of teachers about these outlines.

- **Interviews with teachers**

Teachers' views about the effects of teaching methods and strategies in the learning process

- **How important do you think it is that the teaching method you adopt has a real effect on the learning if it is used in a correct way?**

All teachers involved in the experiment believe that there is a real effect of the teaching method that the teachers use in the mathematics classroom on the learning process and students' outcomes because it is the tool that the teachers use to pass the information to students if it is applied in correct way. They commented that, if the teachers choose the suitable teaching method and strategies according to the situation which exists in the class and use it in a correct way, it would give good results in the learning process.

Teachers in the cooperative group highly supported the positive effect of the teaching method on the learing process when they applied cooperative learning and pointe to the cooperation from the students themselves to apply it in a correct way. Some of these responses are given below.

> " Of course the teaching method has its effects on the learning process and I noticed that when we applied cooperative learning in a correct way after the training I found that it had a positive effect in different domains."
>
> Male teacher, cooperative group.

> " Yes, sure it is very important. If you work in a correct way you will gain good results. I really found that changing the teaching method had a real positive effect in the learning process and that it supported the affect of the teaching method on the learning process. Well, if you give students a right scientific method and if the cooperation exists between the teacher and the students, why don't we achieve a positive effect in our schools?"
>
> Female teacher, cooperative group.

While teachers in the traditional classes believe that the teaching method has an effect in the learning process they also pointed to other factors, such as the quality of the students and the role of their relatives, because all of them combine together in achieving a positive effect on the learning process which was not observed, especially in the male group. However, the next investigations explore more teachers' views about the rationality to use the applied teaching method.

> " Yes, it has its effect, but I think that the effect of the teaching method is usually observed on middle achieving students because high achieving students accept anything introduced to them in any way and the low achieving student does not accept anything introduced to her."
>
> Female teacher, traditional group.

> " Actually, if the teacher chooses the suitable teaching method and applies it in the class in a correct way, of course it has a positive effect. But I think the teaching method we applied is not suitable for all students' standards because it is difficult to follow all of them, to evaluate them and to cure their weaknesses."
>
> Male teacher, traditional group.

> " Without any doubt it has a real effect if it is applied correctly with the shared cooperation between the teacher and the students even students' relatives too because the student is aware of the combination between these factors and, hence, he will reduce his negative attitudes and then participate in the success of the learning process."
>
> Male teacher, traditional group.

Teachers' views about the rationality for using the teaching method

- **Do you consider the teaching method you applied as a rational one in teaching mathematics? Why?**

Teachers who applied cooperative learning were very satisfied with the rationality for using this teaching method, especially in the mathematics classroom, because they found that it was useful for students and also for them.

> " Yes, yes, because it facilitates the teacher to deal with seven groups instead of forty two students, it gives students a good chance to help each other and participate in solving. Moreover, I have more opportunity to evaluate their solutions. Students provide others with the assistance and help they need, especially from high achieving students to low achieving ones. Also, we cannot ignore the students' interest in working in groups."
>
> Female teacher, cooperative group.

> " Yes, because I think there is no better method than using the cooperative teaching method because there are a lot of questions and worksheets that could not be solved unless by using the cooperative method. Moreover, because this subject is a very inanimate one we want to break this hardness by introducing it in an interesting way. In addition to that, it is a difficult subject and the cooperation between students gives low and intermediate achieving students a chance to get benefits from their group mates. For example, following the steps of the solving the mathematical problem is hard and when the students shared and each of them do a specific task, it will reduce the difficulty of solving the problem."
>
> Female teacher, cooperative group.

The previous examples of the teachers' responses who applied the cooperative learning strategies illustrate why it was rational to apply this teaching method which has many advantages for both students and teachers in different domains. It helps students to increase their achievement and promote their mathematical skills; it creates a competitive atmosphere that encourages all students to cooperate and to participate, it makes the atmosphere fun, interesting and exciting. Moreover, it gives the teacher a chance to follow up his/her students, to evaluate and give them feed back and to transfer his/ her role from giving orders and hints into observer and facilitator of learning.

Teachers who applied the traditional teaching methods commented that, although this teaching method gives them a chance to cover all the curriculum material within the specific time and control the class without any disturbance or noise that may occur if the classes are crowded, they felt that this teaching method was not rational because it depends just on the teacher and a few number of students.

> " Well, you know we shall cover all the material within a specific time and our classes are crowded. I think that this method enables me to cover all the material and control the class without any disorder or disturbance".
>
> Female teacher, traditional group.

> " Oh, it is not rational because it depends all the time on the teachers only with a few number of students."
>
> Male teacher, traditional group.

One female teacher commented that

> " Sometimes, yes because we have a large amount of material and I find that the teaching process that the Ministry of Education is concerned with is wrong because it concentrates on quantity not quality. The curriculum is momentum, the lessons are few especially for grades eight and nine and the teacher is exhausted with her hard work. Really, although it is the method that nearly all teachers applied, I think that there must be a more effective and developmental method."
>
> Female teacher, traditional group.

Obviously, teachers used this method because they were used to using it and because they believe that it is the suitable one to cover all the material and keep their classes controlled, but they hoped that they could find more suitable and developmental methods that could help them to find a solution for many of their career's problems.

Teachers' attitudes towards the teaching method

- **How positively is the learning improved by using the cooperative method/ the traditional method?**

All teachers who applied the cooperative learning strategies believe they positively improved the learning process in different indicators: cognitively, effectively, socially and behaviourally. They referred to the changes that had occurred in implementing the cooperative strategies which allow students to interact with others to get the benefits from each other, encourage them to participate in solving problems, give them a chance to do mathematics by themselves and facilitate the teacher by giving him/her the opportunity to follow up all students within their groups to observe, evaluate and give them feed back in the learning process. Some of these responses are given below.

> " Actually, it created interaction between group-mates and hence they got the benefits from each others. Assigning to students specific tasks and roles creates other outcomes like responsibility, altruism, good social relations and improves the level of achievement, especially for intermediate and, to some extent, low achieving students."
>
> Male teacher, cooperative group.

> " The cooperative learning positively affects students' performance in different indications in the cognitive, affective and behaviour domains and promotes different learning skills."
>
> Male teacher, cooperative group.

> " It makes a big change in students' performance which refers to the real implementation for cooperative work as I have discussed previously."
>
> Female teacher, cooperative group.

While teachers in the cooperative group gave positive responses, teachers in the traditional group gave neither positive nor negative responses, except one of the male teachers who commented that the traditional teaching method had a negative effect on the learning process. Actually, most teachers felt that this teaching method is neither useful nor useless and that there is no real affect of applying this method on the learning process. Examples of these responses are given below.

> "I think students are still at the same standard."
>
> Male teacher, traditional group.

> " Actually, negative in spite of my hard efforts "
>
> Male teacher, traditional group.

> " This method is neither useful nor useless."
>
> Female teacher, traditional group.

- **Would you like to continue teaching by using the teaching method in the experiment in all stages you teach? Why?**

All teachers in the cooperative group commented that they should continue to apply this teaching method because of its advantages, especially in the classes with fewer students and suitable furniture. Some of them began to apply it in other classes not involved in the experiment. One male teacher commented that he believed that this teaching method is wonderful and needed to be applied in the upper primary stages but it is not suitable in the basic primary stages because children will not be able to provide others with knowledge that needs much effort. Another one commented that this teaching is less affective in some mathematics lessons which need more interpretation from the teacher. Some of these responses are written below.

> " Yes, because of its advantages that I discussed previously but in some lessons especially if it contains difficult concepts or in the mathematical proofs like some lessons in the circle unit. I felt that using cooperative learning was less effective in such lessons because they need a lot of interpretation and discussion by the teacher."
>
> Male teacher, cooperative group.

> " Yes, but not for all stages especially the basic primary stage, because the child depends on the teacher and the teacher's speech is a holy thing for him in that stages. Also, because these stages need hard efforts that the other children may not be able to provide his friend with such efforts. But in the upper primary stage I think it is wonderful and needs to be applied."
>
> Male teacher, cooperative group.

> " Yes of course, and I have already begun to apply it in other classes not involved in the experiment because of the advantages I found."
>
> Female teacher, cooperative group.

> "Of course, yes, especially if the class contains fewer students and more suitable furniture."
>
> Female teacher, cooperative group.

Some teachers in the traditional group felt that they should use this teaching method because they used to use it and because they believe that it helps them to finish the contents of the curriculum of the textbook that must be covered within a specific time. One male teacher commented that he did not want to continue and he hoped to apply a more useful method.

" Yes, because we used to use it."
Female teacher, traditional group.

" No, because of the hard efforts that the teacher gives generously with useless outcomes. I hope to apply a more useful method."
Male teacher, traditional group.

"Yes, because most of the mathematical material in the curriculum can be taught by using cooperative learning."
Female teacher, traditional group.

- **How do you feel about this teaching method of instruction in mathematics?**

The feelings of teachers in the cooperative group were highly positive; they felt comfortable and happy within the interesting, exciting and cooperative atmosphere. One teacher commented that it is a typical method for teachers and for students, too.

" A positive feeling because it is considered a typical mathematics teaching method for me and I think for students too."
Male teacher, cooperative group.

" I feel comfortable with the cooperative, interesting and exciting atmosphere."
Male teacher, cooperative group.

" A happy feeling."
Female teacher, cooperative group.

The responses of teachers in the traditional group illustrated the normal feeling that may be referred either to the students' performance in the lesson or because they felt that it is just a usual traditional one that suits the teachers' career situation. Some of these responses are quoted below.

" You could say that the usual traditional teaching method is suitable for us to cover the mathematical material in the curriculum within a specific period of time where also the number of the weekly lessons are few compared with the amount of the material."
Female teacher, traditional group.

" Normal."
Male teacher, traditional group.

> " Well, it depends on the students' performance in the lesson. Sometimes I feel comfortable but most times disappointed."
>
> Male teacher, traditional group.

The previous investigations explored the positive attitudes of the teachers in the cooperative group. They felt comfortable and happy in applying it within an interesting and exciting atmosphere. They observed the positive effect on the learning process in different domains and they would like to continue applying it especially at the upper basic primary stage. The attitude of teachers in the traditional group towards the teaching method was mostly neither positive nor negative. They felt that it is neither useful nor useless. It has no real effect on students' outcomes in the learning process. In addition, they should continue using it because they are used to using it unless they found a more suitable and useful one.

The teachers' views of the students' assessment of the teaching method

- **Have you heard or noticed that the students agree or disagree to deal with the traditional/new teaching method?**

All teachers in the cooperative learning classes had either heard or noticed some students' agreement or otherwise about cooperative learning. They found that high achieving students refused to apply it and some of them were frustrated while other intermediate and most of the low achieving agreed to apply it. It was found that there was a strong desire from those students to apply cooperative learning. This was noticed where students were ready for the group work by preparing the material and arranging the classroom physically for the group learning.

> " Yes, I heard. The high achieving student complained about this method because, although he spent most of the time in helping other students, he might miss the leading role. But most students especially middle achieving students, were mostly satisfied with cooperative learning and happy to use it".
>
> Male teacher, cooperative group.

> " Yes I felt that there was a strong desire from the students to apply cooperative learning, nearly 90%."
>
> Male teacher, cooperative group.

> " At the beginning they refused to apply it but after a period of time I noticed that they were very interested to apply it and there was a strong desire from the students for applying this method. When I entered the class, I found them ready, the classroom well arranged, calm and ready for group learning."
>
> Female teacher, cooperative group.

With respect to teachers in the traditional classes, some of them commented that they did not know because it used to be applied in most classes and students were not asked about their opinion in applying this teaching method. Other teachers mentioned that some students in the classes had asked their teachers to apply group learning like other students in the cooperative experimental classes.

> " I did not ask the students if they agree or disagree to use this teaching method. However, it is the usual teaching method involved in most classes."
>
> Female teacher, traditional group.

> " Some students asked to apply the cooperative method like their friend in the other experimental classes."
>
> Male teacher, traditional group.

> " Yes, sometimes in year seven and eight they ask to apply the group method."
>
> Female teacher, traditional group.

Advantages and disadvantages of the teaching method

- **What are the advantages and disadvantages of the teaching method you apply?**

This question was the last one in the open discussion interview conducted with teachers to analyse their views of the advantages and disadvantages of the two teaching methods involved within the experiment. Most teachers in the cooperative group commented that the advantages of cooperative learning were mentioned previously within the discussion through the interviews. These include the positive effect for applying cooperative learning on students' mathematical achievement in different aspects, on students' problem solving skills, on their behaviour and attitude towards mathematics and their classmates. In addition, they mentioned some of the disadvantages they observed which are related to the present situation in Jordanian schools. They hoped that some of these things may be changed one day to offer more opportunities for solving most problems that may handicap the teacher in applying a new developmental teaching method more effectively.

Actually, most of the disadvantages mentioned are not related directly to the teaching method itself, but mostly refer to the available resources and instruments in Jordanian schools.

However, in spite of the disadvantages mentioned within the interviews, teachers had different opinions about it. These problems were different from one class to another which may refer to the quality of the students or gender differences. For example, teachers in the male cooperative group had a problem in arranging the classroom physically because they had no suitable furniture, moreover, because this caused a noise in the class. Female cooperative teachers did not refer at all to this problem, but, in converse, they found that the girls were very cooperative in preparing everything before the teacher arrived in the class. In addition, teachers in the traditional classes had different perspectives about the advantages and disadvantages of this teaching method. However, to present the advantages and disadvantages of the two experimental teaching methods more accurately for the reader, the total findings and results for all points mentioned in the views of teachers and students are given in figures 8.1 and 8.2.

Figure 8.1
Summary of the cooperative learning advantages and disadvantages in the mathematics classroom in the views of Jordanian teachers and students.

Cooperative Learning Advantages	Cooperative Learning Disadvantages
- Creates a cognitive atmosphere. - Creates a competitive atmosphere. - Increases students' achievement in different fields, cognitively and affectively. - Promotes problem-solving skills. - Develops other skills like reading and writing skills, communicating skills, computational skills, social skills and critical thinking. - Improves inter-group relations. - Allows students to speak mathematically. - Encourages students to be independent and, hence, they do mathematics by themselves. - Gives all students a chance to participate in mathematical problems. - Encourages students to interact within their groups to get benefits from each other. - Helps some learning difficulties. - Gives a feeling of fun, interest and excitement in working. - Builds positive attitudes towards mathematics for students and teachers. - Improves students' behaviour and builds a high level of cooperation, altruism, liking class and classmates. - Builds social relations and skills.	- Sometimes it is difficult to build up a successful cooperative activity because of the nature of the lesson that needs teacher intervention frequently which disturbs the cooperative activity. - The group task and spending time in helping low achieving students may cause some kind of frustration for high achieving students. - It may need more time compared with the traditional teaching method because of the side discussion. - It needs some facilities, like the size of the class, the type of furniture, material and resources for teachers, to be applied more effectively. - It cannot achieve its positive effect unless there is good preparation in training teachers in how to use it in the mathematics classroom.

Figure (8.2)

Summary of the advantages and disadvantages of traditional teaching methods in the mathematics classroom in the view of Jordanian teachers and students

Traditional Method Advantages	Traditional Method Disadvantages
- Controls the class without any disturbance. - Offers the opportunity to cover all the material. - Gives the teacher a chance to introduce a lot of information.	- It has no real effect or may affect negatively on increasing students' mathematical achievement. - It has negative effect on students' mathematical problem solving skills. - Depends most of the time on the teacher which makes him/her exhausted at the end of the lesson. - No participation for most students which may not give them any role in the class. - The interaction between students is absolutely absent. - Gives no chance for the teacher to follow up all students, which makes some students go far a way from the lesson. - Students at the back of the class may be cannot see or hear the teacher well. - Routine with no participation and interaction may cause boredom for students and pressure for teachers. - Students' performance compared with the hard efforts of the teacher causes the feeling of disappointment, which may affect negatively on teachers' attitudes towards it. - Prevents students expressing their thoughts because they feel afraid and ashamed to answer in front of all the class. - Does not improve affective or behaviour skills. - It has fewer outcomes in the non-cognitive domain. - The competition is just among high achieving students - No cooperation between students and each of them is independent which causes some kind of selfishness. - Gives no chance for the teacher to assess most students. - It has no effect in the social field.

To support the previous findings of the views of teachers, some of their responses are quoted below.

> " There are no disadvantages related to the teaching method itself."
> Female teacher, cooperative group.
>
> " The advantages are many and in different domains. It increases the students' achievement, especially the intermediate students, and promotes different kind of skills. It gives a chance for students to cooperate and help them to benefit from others. It has a positive effect on their behaviour and the relationship between them."
> Male teacher, cooperative group.
>
> " Actually, it really gives a chance for the teacher and the students to do their work effectively and the very important thing is that it has a positive effect on students attitudes towards mathematics because I noticed that they became more concerned about mathematics."
> Female teacher, cooperative group.
>
> " There are no advantages."
> Male teacher, traditional group.
>
> " There is no cooperation, each of them is independent and there is a kind of selfishness."
> Female teacher, traditional group.
>
> " It is impossible for the teacher to follow the students, evaluate them and assess their performance."
> Male teacher, traditional group.
>
> " There is a kind of routine and feeling of boredom."
> Female teacher, traditional group.
>
> " I can control the class with no disturbance which gives me time to cover all the material."
> Female teacher, traditional group.

Summary of finding

Previous investigations illustrate that teachers believed that the type of the teaching method adapted in the mathematics classroom had a real effect on the learning process. Teachers in cooperative learning found that it was rational to apply cooperative learning in their classes because of its advantages whenever the type of the mathematical material and the situation in the class is suitable for applying this teaching method. Some teachers in traditional classes were not satisfied when applying the traditional method and others commented that it is suitable to enable them to cover the material within the limited time available.

Teachers in the cooperative classes have positive attitudes towards this teaching method and they believe they should continue to apply this method whenever the situation is suitable. Teachers in the traditional classes gave neither positive nor negative attitudes except one teacher who had a negative response. In the view of teachers, most students want to apply cooperative learning except high achieving students. Some students in traditional classes asked their teachers to apply cooperative learning like the other classes involved in the experiment, while other teachers had no idea about their students' responses.

Several advantages and disadvantages of the cooperative and traditional method had been explored during the interviews with teachers and students which are summarised in figures 8.1 and 8.2.

8.4 Fourth Issue: Attitudes toward mathematics

Assessment of students' attitudes toward mathematics

It is very important to measure the attitudes of students in such research because there may be a strong relationship between students' attitudes and achievement related to the effect of teaching methods involved within the experiment which is to be measured and analysed here.

Many studies have been concerned with measuring attitudes towards mathematics (Wheeler and Ryan, 1973; Johnson et al, 1976; Slavin, 1978; Artzt, 1979; Peterson and Janicki, 1979; Sharan, 1980; Slavin and Karweit, 1985; Schoenfeld, 1989; Owens et al, 1998; Yusof and Tall, 1999 and others) and most of them have found that cooperative learning positively effects students' attitudes towards mathematics. However, at this stage the researcher used several instruments to measure students' attitudes towards mathematics as complementary to each other by applying the questionnaire to all students and conducting interviews with a sample of them. The following discussion for the quantitative and qualitative analytical stage will analyse the students' attitudes towards mathematics and will answer the research questions for this issue of the research study.

- **The quantitative part**

The questionnaire (part three)

The questionnaire was used for the quantitative part of this issue (see appendix three, part three) to assess students' attitudes towards mathematics. Means and standard deviation for this part of the questionnaire were calculated previously (see table 8. 10).

Since there are differences in the means and the standard deviations, multivariate analysis of variance (MANOVA) was used to assess if there were statistically significant differences in the students' responses towards this part of the questionnaire (as a dependent variable) related to the effect of teaching method, gender and the interaction between teaching method and gender (as independent variables) (see table 8.11).

Remark: for the effect of the interaction between teaching method and gender see appendix nine (b).

Table 8.11 (with respect to part three of the questionnaire) reveals that

1. There are statistically significant differences in the students' attitudes towards mathematics related to the teaching method.

Comparing means in table 8.10 indicated that the mean of the total cooperative group was more than the mean of the total traditional group (3.5698 > 3.2057) with statistical differences. This means that those students' attitudes towards mathematics were more positive than those in the traditional classes. Hence:

- Hypothesis 16. H0 is rejected.
- Hypothesis 16. H1 is accepted.

Remark: for hypothesis 16. H0 and 16. H1 see page 143

2. There are statistically significant differences related to gender (Sig. $0.003 < 0.05$).

   That means that there are gender differences in students' attitudes towards mathematics in the female and male groups. Comparing means in table 6.10 indicates that the attitudes of the male students towards mathematics were more positive than the female students with statistically significant differences. Previous findings indicate that:

   - Hypothesis 17. H0 is rejected.
   - Hypothesis 17. H1 is accepted.

   Remark: for hypothesis 17. H0 and 17. H1 see page 143

3. There are statistically significant differences in students' responses towards this part of the questionnaire related to the interaction between teaching method and gender (see appendix nine (b)). Hence:

   - Hypothesis 18. H0 is rejected.
   - Hypothesis 18. H1 is accepted.

Comparing means in table 8.10 show these differences. While students' attitudes towards mathematics in the two female and male cooperative groups were more positive than those in the traditional classes, attitudes of the male students in the two cooperative and traditional groups were more positive than female groups in the cooperative and traditional classes. This result indicates that cooperative learning strategies affect more positively on students' attitudes towards mathematics than the traditional teaching strategies and the effects of the two teaching strategies on the male group were more positive than on the female group.

For more discussion on the differences in students' attitudes towards mathematics and how the teaching method affected on their attitudes, frequencies and percentages for this part of the questionnaire were calculated and will be analysed within this stage. Moreover, the qualitative data analysis explores students' and teachers' views about how the teaching method affected students' attitudes towards mathematics and will indicate if there were other factors that may affect their attitudes other than the teaching method. However, all of these findings are explained during the analytical stages and discussed more accurately.

The following stage explains students' responses towards this part of the questionnaire. Table 8.14 represents these frequencies and percentages.

Table 8.14

Frequencies and percentage of the students' responses (agreement, uncertainty and disagreement) towards the items of part 3 of the questionnaire
Part three: students' attitudes towards mathematics

Item	TM	G	Agreement		Uncertainty		Disagreement	
			Frq.	Per.%	Frq.	Per.%	Frq.	Per.%
1. Mathematics is a difficult subject and needs a lot of effort to be understood.	C	F	13	15.12	3	3.49	70	81.40
		M	28	32.94	14	16.47	43	50.59
	T	F	15	16.85	7	7.87	67	75.28
		M	12	14.12	6	7.06	67	78.82
2. I like teaching mathematics and solving mathematical problems.	C	F	54	62.79	6	6.98	26	30.23
		M	64	75.29	15	17.65	6	7.06
	T	F	44	49.44	14	15.73	31	34.83
		M	59	69.41	5	5.88	21	24.71
3. It is possible to simplify the mathematical information in a way that it is easy to be understood.	C	F	67	80.72	9	10.84	7	8.43
		M	67	80.72	9	10.84	7	8.43
	T	F	70	78.65	6	6.74	13	14.61
		M	62	72.94	10	11.76	13	15.29
4. I am always afraid of failing in mathematics.	C	F	17	20.00	9	10.59	59	69.41
		M	38	44.19	15	17.44	33	38.37
	T	F	16	18.18	2	2.27	70	79.55
		M	25	30.12	11	13.25	47	56.63
5. Mathematics is useful for me to organise my special life situations.	C	F	58	67.44	15	17.44	13	15.12
		M	58	67.44	14	16.28	14	16.28
	T	F	46	54.12	12	14.12	27	31.76
		M	48	56.47	9	10.59	28	32.94
6. Mathematics is not related to any other school subjects.	C	F	58	68.24	7	8.24	20	23.53
		M	67	78.82	5	5.88	13	15.29
	T	F	52	59.77	5	5.75	30	34.48
		M	60	70.59	5	5.88	20	23.53
7. There are many applications in the daily life and social fields.	C	F	73	84.88	4	4.65	9	10.47
		M	75	87.21	6	6.98	5	5.81
	T	F	46	53.49	13	15.12	27	31.40
		M	56	65.88	10	11.76	19	22.35
8. Learning mathematics helps me to solve my problems in the daily life.	C	F	45	52.33	22	25.58	19	22.09
		M	52	60.47	15	17.44	19	22.09
	T	F	32	36.36	15	17.05	41	46.59
		M	40	47.62	10	11.90	34	40.48
9. I like mathematics less than I used to.	C	F	29	34.12	16	18.82	40	47.06
		M	42	50.00	11	13.10	31	36.90
	T	F	39	43.82	8	8.99	42	47.19
		M	51	61.45	10	12.05	22	26.51

10. Learning mathematics is a wide field for discovery and development.	C	F	61	72.62	8	9.52	15	17.86
		M	66	77.65	8	9.41	11	12.94
	T	F	56	63.64	13	14.77	19	21.59
		M	57	67.86	8	9.52	19	22.62
11. Mathematics subject does not stimulate the attention.	C	F	36	41.86	14	16.28	36	41.86
		M	62	74.70	8	9.64	13	15.66
	T	F	38	45.78	12	14.46	33	39.76
		M	44	51.76	13	15.29	28	32.94
12. Learning mathematics helps me to be more accurate in the work to think in a logical way.	C	F	64	74.42	10	11.63	12	13.95
		M	69	81.18	10	11.76	6	7.06
	T	F	50	58.82	15	17.65	20	23.53
		M	47	55.95	15	17.86	22	26.19
13. I do not like mathematicians or those who work in mathematical sciences.	C	F	39	46.43	6	7.14	39	46.43
		M	55	63.95	19	22.09	12	13.95
	T	F	42	47.19	13	14.61	34	38.20
		M	48	56.47	11	12.94	26	30.59
14. I need always to someone who helps me in learning mathematics in order to success.	C	F	64	74.42	11	12.79	11	12.79
		M	49	56.98	17	19.77	20	23.26
	T	F	59	66.29	5	5.62	25	28.09
		M	56	66.67	8	9.52	20	23.81
15. Mathematics is an attractive subject.	C	F	37	43.02	17	19.77	32	37.21
		M	63	73.26	9	10.47	14	16.28
	T	F	36	42.35	10	11.76	39	45.88
		M	42	49.41	10	11.76	33	38.82
16. Mathematical concepts are not complex and can be understood.	C	F	32	38.55	19	22.89	32	38.55
		M	46	54.76	22	26.19	16	19.05
	T	F	33	37.93	15	17.24	39	44.83
		M	40	47.06	14	16.47	31	36.47
17. I like solving puzzles and games which are solved mathematically.	C	F	58	67.44	9	10.47	19	22.09
		M	67	78.82	6	7.06	12	14.12
	T	F	47	52.22	11	12.22	32	35.56
		M	47	55.29	11	12.94	27	31.76
18. I hope to be a mathematics teacher in the future.	C	F	24	28.24	7	8.24	54	63.53
		M	22	25.88	26	30.59	37	43.53
	T	F	13	14.44	6	6.67	71	78.89
		M	27	31.76	11	12.94	47	55.29
19. Mathematics is the basis of scientific improvement and modern technology.	C	F	73	85.88	3	3.53	9	10.59
		M	74	86.05	7	8.14	5	5.81
	T	F	74	82.22	5	5.56	11	12.22
		M	57	67.06	11	12.94	17	20.00
20. I feel bored when others talk about mathematics in front of me.	C	F	32	37.21	16	18.60	38	44.19
		M	59	68.60	15	17.44	12	13.95
	T	F	48	53.33	9	10.00	33	36.67
		M	46	54.12	16	18.82	23	27.06

TM: Teaching method.
G: Gender.
C: Cooperative.
T: Traditional.
F: Female.
M: Male.

Table 8.14 shows that

1. Items 1, 2, 3 and 4 reveal that most students in the two groups disagree that mathematics is a difficult subject and needs a lot of effort to be understood, except the male cooperative group; those had less disagreement. The cooperative female and male groups were more positive towards liking the teaching of mathematics and solving mathematical problems. Moreover, they believe that it is possible to simplify mathematical information in a way that makes it easy to be understood more than those in the female and male traditional classes, respectively. In spite of their responses towards these items the cooperative female and male groups are more afraid of failing in mathematics. Actually, this may refer to their ability and their beliefs that mathematics is a difficult subject to be understood, like the response to item 1 of the male students in the cooperative group or the researcher's beliefs that, because those students apply a new method of teaching, they may be worried about the results of applying such a new method and this may reflect on their feeling. However, it is clear that cooperative learning affects positively for liking mathematics and feeling that it is possible to be simplified and understood.

2. Items 5, 6, 7 and 8 indicate that the female and male cooperative students believe that mathematics is useful for them to organise their special life situations, it helps them to solve their problems in the daily life and there are many applications in social fields more than those in the traditional classes. Despite that response, most students in the two experimental groups agree that mathematics is not related to any other school subject. Moreover, the percentage in the cooperative group who believes that mathematics helps them to solve their problems in the daily life is not very high like the other two items (items 5 and 7). This could be referred to different reasons (as discussed in the different parts). One of them is that, teachers in their classes used not to link mathematics and other subjects and they are poor in introducing mathematical subjects in a practical way to enable students link them with daily life situations and their applications (see questionnaire, part two, item 10, p.223). The second reason may be related to the effect of the teaching method involved in their

classes to highlight the importance of mathematics in our daily life situations (see interviews with students, pp.257-258)

3. Items 9, 10, 11, 12 and 13 show that students in the female and male traditional classes are more in agreement that they like mathematics less than those in the female and male cooperative learning classes, respectively. This highlights the fact that cooperative learning affects positively towards students' attitudes to liking mathematics more than they used to. These new feelings may refer to their interest in applying cooperative mathematics lessons and using the new strategies that break the barrier between the students and the mathematical problems and encourage them to try as a group to solve these problems. This point will be analysed more qualitatively through the interviews with students. Moreover, students in the cooperative learning classes were more positive to see that learning mathematics is a wide field of discovery and development and helps them to be more accurate in the work and to think in a logical way than those in the traditional classes. In items 11 and 13 the researcher believes that students' responses to those items correspond to each other. The female cooperative group has the same percentage of agreement and disagreement to the two items which indicate that they believe that mathematics does not stimulate the attention and they do not like mathematicians or those who work in that field. In spite of that, it is clear that the female cooperative group were more positive than the female traditional group to see mathematics stimulate the attention and to like mathematicians or those whom work in that field. The male students' response is different here, where the traditional male group was more positive towards these items. Actually, this may also refer to their satisfaction and relationship with their teacher.

4. Items 14, 15, 16 and 17 reveal that the female cooperative group and the male traditional group see more than the other groups, respectively, that they always need someone to help them in learning mathematics. This may refer to their ability in mathematics. However, most of them in the two experimental groups are in more agreement that they need this assistance. Also, it is obvious that the cooperative group more positively sees mathematics as an attractive subject and

its concepts not very complex to be understood than those in the traditional classes. Moreover, they like puzzles and games that are solved mathematically.

5. Items 18, 19 and 20 show that most students would dislike to be mathematics teachers in the future. The female and male cooperative group more positively believe that mathematics in the basis of scientific improvement and modern technology and, in spite of that, most of them feel bored when others are talking about mathematics in front of them, except those in the female cooperative group.

Summary of previous quantitative findings in part three of the questionnaire

The previous findings indicate that cooperative learning affects more positively on students' attitudes towards mathematics than on those in the traditional classes with gender differences where male students were more positive than the female group. Actually, as has been discussed, measuring attitudes in not a simple task because it deals with feelings, beliefs and values which may differ from one situation to another or from time to time. However, the most important task here is to assess if the teaching method affects students' attitudes or not and, generally, the results here support the cooperative learning effects. For more assessment about the effect of the teaching method on students' attitudes towards mathematics, and in order to explore if this feeling is a new one related to the effect of the teaching method, the qualitative part comes as complementary to the quantitative one for this issue.

The Qualitative Part

Interviews with students

Previous quantitative data analysis indicated that cooperative learning positively affects students' attitudes towards mathematics compared with the attitudes towards mathematics in the traditional group. The most important finding in the previous stage is that quantitative results illustrated that there was no relationship between students' mathematical achievement and their attitudes towards mathematics as a whole. While the achievement of the female students is more than the achievement of the male students in the two experimental groups, the attitudes of male students towards mathematics was more positive than the attitude of female students in the experimental groups.

The following qualitative data analysis for the questions related to this issue that were highlighted within the interviews with students explores how the teaching method may affect students' attitudes towards mathematics.

- **Are you interested in mathematics lessons and do you look forward to them? Is this a new feeling? Why?**
- **Do you like mathematics? Why?**

The responses of students in the cooperative group indicated that applying this new teaching method builds new feelings of interest and looking forward to the mathematics lessons, especially for low and intermediate achieving students.

> " Yes, yes. Actually when we apply the cooperative method I became to like mathematics more than before and look forward to the lesson."
>
> Female student, cooperative group.

> " Of course and it is a new feeling born because of the cooperative method that creates an interesting and wonderful environment for learning."
>
> Male student, cooperative group.

> " Yes, oh, I don't know but I discovered that I have tendency towards it."
>
> Female student, cooperative group.

Investigations also found that high achieving students had different feelings. Although they like mathematics because it is an important subject that encouraged critical thinking and they look forward to the lessons because they are interested in mathematics, they are not interested in applying cooperative learning because they felt that, in this method, they spent most of the time helping other students which gave them less chance to participate in the class than before.

> " Oh. I like it so much. It is a wonderful subject that activates the mind and I feel very interested in solving problems, but I don't prefer the cooperative method because I waste my time in the group-work and it does not give me a chance to participate in the class as before."

Male student, cooperative method.

Some students in the traditional group commented that they were not interested in mathematics and they did not like it because it is a difficult subject and they cannot understand it well. Others felt that the mathematics lessons are boring and did not stimulate the attention. Some of these comments are given below.

> " No, because I feel that the mathematics lessons are boring and do not stimulate the attention."
>
> Male student, traditional group.

> " Not so much, because it is a difficult subject."
>
> Female student, traditional group.

Some students commented that, although they hate mathematics, they began to like mathematics lessons because they have a good relationship with the teacher.

> " Although I hate mathematics, I like my teacher and I like his lessons."
>
> Male student, traditional group.

Also, investigations explore that high achieving students like mathematics and they felt very interested in mathematics lessons because they participate in solving problems and get first place in the class.

> " I like mathematics, it is very interesting and I always take the first place in the class."
>
> Female student, traditional group.
>
> One male student said:
>
> " I like mathematics because it is a subject that is understood and not memorised."
>
> Male student, traditional group.

- **Does the teaching method highlight the importance of mathematics and its effect in your thinking to solve problems in different new daily life situations? If yes, how? If no, why?**

During the interviews with female and male students in the two experimental groups it was noticed that, especially with respect to the last question that assesses students' beliefs about the effect of learning mathematics to solve problems in our daily life situations, investigations illustrated that male students have a more positive attitude towards mathematics and towards its significance in our daily situations because they believe that this scientific subject is very important in our life. It is used in different fields everywhere and all the time. They felt that they should pay attention to such a subject because it is important in GCSE. Moreover, they prefer to study subjects that need to be understood and need not be memorised. Also, students in the cooperative group were more in agreement that applying cooperative learning in solving mathematical problems let them taste the joy of mathematics by using mathematics to solve problems in our daily life situations. Some of these commented are quoted below.

> " I like it because it needs to be understood, not to be memorised."
>
> Male student, traditional group.

> " Actually, it is a very important subject in the GCSE, we must succeed in mathematics to continue our higher studies."
>
> Male student, traditional group.

> " The cooperative method lets us taste the joy of mathematics to apply it in our daily life situations."
>
> Female student, cooperative group.

> " We need mathematics everywhere and all the time, so it is very important in our life."
>
> Female student, traditional group.

Summary of findings

Quantitative and qualitative data analysis indicated that cooperative learning positively affects students' attitudes towards mathematics more than those in the traditional group. This is because it creates an exciting environment for learning in an interesting and fun way with less agreement from high achieving students who felt that they spent their time in helping others and that makes them miss the first place in the class. Findings also revealed that there was no relationship between students' achievement in mathematics and students' attitudes towards it. While female students achieve more than male students, the attitudes of male students were more positive than females because they believe more that it is a scientific subject that is needed everywhere and all the time; it is important for many applications in our daily life situations, to continue higher studies and because it activates the mind as it needs to be understood and not memorised or because of the good relationships that were built between them and their teachers. One basic reason for these differences may be the gender difference.

8.5 Fifth Issue: Outcomes other than achievement

Assessment of students' outcomes other than achievement in the non-cognitive domain

Cooperative learning is a social method. It has been shown in a wide variety of studies that cooperative learning positively influences many important non-cognitive variables. This part of the study assesses outcomes other than achievement, such as inter-group relationship, acceptance of mainstreamed academically handicapped students, self-esteem, peer academic support, internal locus of control and liking of school, class and classmates. The fourth part of the questionnaire is used for this issue in the quantitative analysis stage and had been completed within the interviews conducted with teachers and students. The following discussion for the quantitative and qualitative analytical stage explores other expected outcomes in the non-cognitive domain.

- **The quantitative part**

The questionnaire (part four)

The questionnaire was used for the quantitative part for this issue (see appendix three, part four) to assess students' outcomes other than achievement in the non-cognitive domain. Means and standard deviation for this part of the questionnaire were calculated previously (see table 8. 10).

Since there are differences in the means and the standard deviations, multivariate analysis of variance (MANOVA) was used to assess if there are statistically significant differences in the students' responses towards this part of the questionnaire (as a dependent variable) related to the effect of teaching method, gender and the interaction between teaching method and gender (as independent variables) (see table 8.11).

Remark: for the affect of the interaction between teaching method and gender see appendix nine (b).

Table 8.11 (with respect to part four of the questionnaire) reveals that:

1. There are statistically significant differences in the students' outcomes other than achievement related to the teaching method. Hence:
   - Hypothesis 19. H0 is rejected.
   - Hypothesis 19. H1 is accepted.

<u>Remark</u>: for hypothesis 19.H0 and 19.H1 see page 143-144.

Comparing means in table 8.10 indicated that the mean of the total cooperative group was more than the mean of the total traditional group (3.5523 >3.3029) with statistically significant differences. This means that students in the cooperative group gain more outcomes in the non-cognitive domain compared with those in the traditional classes.

2. There are no statistically significant differences related to gender (Sig. 0.889 > 0.05). Hence:
   - Hypothesis 20. H0 is accepted.
   - Hypothesis 20. H1 is rejected.

<u>Remark</u>: for hypothesis 20.H0 and 20.H1 see page 144.

That means there are no gender differences in students' outcomes in the non-cognitive domain in the female and male groups.

3. There are statistically significant differences in students' responses towards this part of the questionnaire related to the interaction between teaching method and gender (see appendix nine (b)). Hence:
   - Hypothesis 21. H0 is rejected.
   - Hypothesis 21. H1 is accepted.

<u>Remark</u>: for hypothesis 21.H0 and 21.H1 see page 144.

Comparing means in table 8.10 shows these differences. In the two male and female cooperative groups the responses of the students' towards this part was more positive than those in the traditional classes. While the students in the female and male cooperative groups have nearly the same means, there were few differences in the means of the female and male traditional groups which were more positive in the female traditional group.

For more discussion on the differences in students' outcomes other than achievement and if the teaching method may affect in that field, frequencies and percentages for the items of this part (see table 8.15) were calculated and analysed. Moreover, the qualitative data analysis will explore students' and teachers' views about how the teaching method affected students' outcomes other than achievement.

The following stage explains students' responses towards this part of the questionnaire.

When the researcher designed this part of the questionnaire, each group of items was designed to search specific outcomes, as discussed in detail in chapter seven. However, the following discussion explores these outcomes.

Table 8.15 reveals that

1. Items 1, 2, 3 and 4 **(inter-group relationships)** show that most female and male students in cooperative classes agree that their relationship with their classmates is stronger than before; they deal with their classmates who are not in the same social class and they believe that cooperation with classmates is useful for all of them, more than students in the traditional classes. Since the percentage of students who prefer to solve the mathematical problems alone without any help from their classmates is less than those who disagree, in all groups and, although the percentage in the traditional classes presents that they are more in agreement to prefer their classmates' assistance, this did not mean that the cooperative classes were less cooperative but this highlights the point that students in the traditional group hope to get such assistance. This fact is supported by their previous response where most of them in all the cooperative and traditional classes see that cooperation with classmates is useful for all of them. These items reveal that cooperative learning positively affects students' inter-group relationships.

Table 8.15
Frequencies and percentage of the students' responses (agreement, uncertainty and disagreement) toward the items of part 4 of the questionnaire

Part four: Outcomes other than achievement

Item	TM	G	Agreement		Uncertainty		Disagreement	
			Frq.	Per.%	Frq.	Per.%	Frq.	Per.%
1. My relationship with my classmates is stronger than before.	C	F	73	84.89	6	6.98	7	8.14
		M	75	87.21	5	5.81	6	6.98
	T	F	31	34.44	11	12.22	48	53.33
		M	47	55.29	6	7.06	32	37.65
2. I deal with my classmates who are not the same as my social class.	C	F	72	84.71	3	3.53	10	11.76
		M	68	79.07	3	3.49	15	17.44
	T	F	75	84.27	2	2.25	12	13.48
		M	53	62.35	15	17.65	17	20.00
3. Cooperation with the classmates is useful for all of us.	C	F	78	90.70	3	3.49	5	5.81
		M	79	91.86	4	4.65	3	3.49
	T	F	78	86.67	3	3.33	9	10.00
		M	68	80.95	2	2.38	14	16.67
4. I prefer to solve the mathematical problems by myself without any help of any from my classmates.	C	F	30	35.71	14	16.67	40	47.62
		M	23	26.74	18	20.93	45	52.33
	T	F	30	33.33	12	13.33	48	53.33
		M	29	34.12	5	5.88	51	60.00
5. Low achieving students have a chance for success.	C	F	52	61.18	8	9.41	25	29.41
		M	53	61.63	20	23.26	13	15.12
	T	F	36	40.00	16	17.78	38	42.22
		M	33	38.82	11	12.94	41	48.24
6. All of the students have equivalent chances in learning and in contributing during the class activities.	C	F	71	83.53	6	7.06	8	9.41
		M	61	71.76	12	14.12	12	14.12
	T	F	45	50.56	13	14.61	31	34.83
		M	52	61.18	10	11.76	23	27.06
7. The actual contribution in the class is for the high achieving students.	C	F	14	16.47	11	12.94	60	70.59
		M	20	23.53	12	14.12	53	62.35
	T	F	29	32.58	9	10.11	51	57.30
		M	36	42.35	6	7.06	43	50.59
8. Learning disabilities cause a barrier against the development.	C	F	43	50.59	18	21.18	24	28.24
		M	48	56.47	16	18.82	21	24.71
	T	F	40	44.94	21	23.60	28	31.46
		M	39	45.88	12	14.12	34	40.00
9. I do not like to deal with low achieving students.	C	F	45	53.57	23	27.38	16	19.05
		M	59	70.24	11	13.10	14	16.67
	T	F	56	62.92	7	7.87	26	29.21
		M	39	46.43	15	17.86	30	35.71
10. Choosing my friends depends on their academic achievement.	C	F	29	34.12	11	12.94	45	52.94
		M	24	28.24	17	20.00	44	51.76
	T	F	31	36.90	17	20.24	36	42.86
		M	31	36.90	17	20.24	36	42.86
11. I believe that I am valuable and important.	C	F	52	62.65	17	20.48	14	16.87
		M	64	76.19	11	13.10	9	10.71
	T	F	51	56.67	13	14.44	26	28.89
		M	54	64.29	10	11.90	20	23.81
12. I am confident to make my decisions by myself.	C	F	8	9.52	11	13.10	65	77.38
		M	15	17.44	12	13.95	59	68.60
	T	F	18	20.69	7	8.05	62	71.26
		M	17	20.48	7	8.43	59	71.08

13. I feel that I am not well liked by my peers.	C	F	54	64.29	11	13.10	19	22.62
		M	50	59.52	14	16.67	20	23.81
	T	F	55	62.50	10	11.36	23	26.14
		M	36	42.86	14	16.67	34	40.48
14. I feel that I am doing well academically.	C	F	65	79.27	11	13.41	6	7.32
		M	63	75.00	13	15.47	8	9.52
	T	F	50	56.82	19	21.59	19	21.59
		M	60	72.29	10	12.05	13	15.66
15. Teaching method goals create peer norms that support high achievement.	C	F	51	60.00	20	23.53	14	16.47
		M	48	56.47	10	11.76	27	31.76
	T	F	41	46.07	14	15.73	34	38.20
		M	39	45.88	13	15.29	33	38.82
16. There are incentives that motivate students to try to get each other do academic work.	C	F	60	70.59	6	7.06	19	22.35
		M	63	73.26	8	9.30	15	17.44
	T	F	63	70.00	6	6.67	21	23.33
		M	54	64.29	7	8.33	23	27.38
17. I feel that my classmates do not want me to do my best.	C	F	30	35.29	41	48.24	14	16.47
		M	45	53.57	19	22.62	20	23.81
	T	F	47	52.22	15	16.67	28	31.11
		M	38	45.24	12	14.29	34	40.48
18. I believe that my academic success depends on my own effort.	C	F	17	20.73	13	15.85	52	63.41
		M	24	28.24	8	9.41	53	62.36
	T	F	33	37.08	11	12.36	45	50.56
		M	35	41.67	8	9.52	41	48.81
19. I feel that my outcomes depend on luck rather than my performance.	C	F	65	76.47	8	9.41	12	14.12
		M	61	71.76	5	5.88	19	22.35
	T	F	62	68.88	8	8.89	20	22.22
		M	50	59.52	10	11.90	24	28.57
20. We spend more time working on the academic tasks than before..	C	F	68	80.95	10	11.9	6	7.14
		M	64	75.29	14	16.47	7	8.24
	T	F	69	77.53	9	10.11	11	12.36
		M	58	68.24	10	11.76	17	20.00
21. I do not like the school.	C	F	33	38.82	19	22.35	33	38.82
		M	39	45.88	21	24.71	25	29.41
	T	F	47	52.81	16	17.98	26	29.21
		M	45	52.94	13	15.29	27	31.76
22. I like my class and my classmates.	C	F	64	76.19	11	13.10	9	10.71
		M	63	74.12	12	14.12	10	11.76
	T	F	71	79.78	5	5.62	13	14.61
		M	62	73.81	7	8.33	15	17.86
23. We spend a waste time in the school.	C	F	18	21.44	4	4.76	62	73.81
		M	16	19.28	9	10.84	58	69.88
	T	F	14	16.28	8	9.30	64	74.42
		M	23	27.71	9	10.84	51	61.45
24. I like the cooperative work with my peers.	C	F	63	75.90	11	13.25	9	10.84
		M	58	69.88	11	13.25	14	16.87
	T	F	53	60.92	18	20.69	16	18.39
		M	63	74.12	5	5.88	17	20.00
25. I do not deal with my classmates out of the class.	C	F	61	73.49	12	14.46	10	12.05
		M	60	70.59	10	11.76	15	17.65
	T	F	73	81.11	5	5.56	12	13.33
		M	48	56.47	10	11.76	27	31.76

TM: Teaching method.
G: Gender
C: Cooperative.
T: Traditional.
F: Female.
M: Male.

2. Items 5, 6, 7, 8, 9 and 10 **(acceptance of academically handicapped students)** show that students in the female and male cooperative classes were more in agreement than those in traditional ones that low achieving students have a chance of success and all students have equivalent chances in learning and contributing during class activities. Moreover, they were less in agreement that the actual contribution in the class is for the high achieving students and, although nearly half the students or less in all groups believe that learning disabilities cause a barrier against the development, the cooperative students were more in agreement than the traditional ones. Finally, the female cooperative students were less in agreement than those in the traditional classes that they do not like to deal with low achieving students while the male cooperative students were more in agreement than the traditional ones that they do not like to deal with low achieving students. Despite that, item 10 shows that all students in all groups were less in agreement that choosing their friends depends on their academic achievement, especially the cooperative groups. All the findings in these items illustrate that cooperative learning strategies had positive effects towards acceptance of mainstreamed academically handicapped students than the traditional teaching method but, in spite of that (and especially from students' response toward item 9), the positive effect is not so high to say that cooperative learning really affects students to accept handicapped students. This issue will be highlighted and discussed later on in the qualitative stage of the analysis where most of these responses were for high achieving students.

3. Items 11, 12, 13 and 14 **(self esteem)** show that, although cooperative students were more in agreement that they believe that they are valuable and important and feel that they are better academically than those in the traditional groups. They feel more that they are not well liked by their peers and a few of them are confident to make decisions by themselves. Here the researcher believes that cooperative learning did not have as much effect on students' self esteem as the traditional method.

4. Items 15, 16 and 17 **(peer academic support)** show that students in the female and male cooperative classes were more in agreement that cooperative goals create peer norms which support high achievement and there are incentives that motivate students to try to get each other to do academic work than those in the traditional classes. Moreover, they were less in disagreement than students in the traditional group in feeling that their classmates do not want them to do their best. These responses indicate that cooperative learning positively affected peer academic support.

5. Items 18 and 19 **(locus of control)** show that most students in the two experimental groups do not believe that their academic success depends on their effort and they feel that their outcomes depend on luck rather than their performance, with more negative response in the cooperative group. This illustrates that cooperative learning strategies did not affect positively on locus of control.

6. Item 20 **(time on task)** shows that, although most students in the two experimental groups feel that they spend more time working on the academic task than before, the percentage in the female and male cooperative groups are higher than those in the traditional groups, respectively. In spite of students' responses towards this item, the qualitative data, especially through the lesson observations, illustrates that the differences between the time on task in the two experimental groups is more than that as will be discussed in detail later on, where cooperative learning transfers the learning situation from teacher-centred-approach to student-centred approach which allows students to have more time to work on the academic task because of their interaction and cooperation. However, the high percentage in the female traditional group can be explained by the students' ability in this group which contained many high achieving students. In general, students' responses to this item illustrate that cooperative learning affects positively on time on task which may give a reason to enhance students mathematical achievement.

7. Items 21, 22, 23, 24 and 25 **(liking of school, class and classmates)** show that more students dislike school than like it, especially in the traditional group. Most students in the two experimental groups like their classmates, with more

disagreement in the traditional classes. Most students disagree that they waste time at school. Most students like the cooperative work with their peers especially the female cooperative and the male traditional groups. This may be the result of the high level of the cooperation observed in the female classes and the liking to apply cooperative work in the female traditional classes, as will be explained during the qualitative stage of the analysis. Most students in the two experimental groups do not deal with their classmates out of class, with less agreement in the male traditional group. In general, students' responses towards the previous items indicate that cooperative learning strategies do not affect positively on students' liking of the school but affect positively on liking the class and classmates especially in the female groups. Moreover, they indicate that the relationships between students in the traditional group were also good and they like each other, too.

Summary of previous quantitative findings in part four of the questionnaire

This part of the questionnaire highlights many outcomes and advantages that may be gained from applying cooperative learning strategies. The findings in this part indicate that cooperative learning positively affected on inter-group relationships, peer academic support, time on task and liking of class and classmates. However, some expected outcomes were not achieved and the researcher found that cooperative learning did not affect positively towards acceptance of academically handicapped students, self-esteem, locus of control and liking of school.

The Qualitative Part

During the previous stages of analysing the qualitative data collected within the interviews with teachers and students for the previous issues, and especially in exploring the advantages and disadvantages of the teaching method, many such non-cognitive outcomes expected in the cooperative learning group were observed and mentioned by both the teachers and the students. However, the following questions asked within the interviews with teachers and students highlighted this issue especially and will be supported by some examples of the students and teachers in the two experimental groups.

Interviews with students

Other non-academic achievements in the teaching method

- **Does the teaching method affect other non-academic achievement, for example, the relationship between you and your classmates, your personality, and so on...?**

All students in the cooperative group pointed out that applying the cooperative method generated many outcomes in the non-cognitive domain. They commented that very strong social relationships were built between students in the class especially between students in the same group. These relationships were friendship, cooperation and respect for each other. It created a shift from feelings of fear and shame to solve problems in front of the students on the board with a feeling of confidence and bravery. Liking mathematics, the class and the classmates and the altruism were repeated also in students' answers. Some of these responses are quoted below.

> " I felt that I have a role in the class."
>
> Female student, cooperative group.

> " The cooperation increased the numbers of my friends in the class so the relationship became cooperative and friendly together."
>
> Male student, cooperative group.

> " Yes, there was a very strong social relationship between the girls especially in the one group."
>
> Female student, cooperative group.

> " Of course, yes. It strengthened my self confidence and I began to depend on myself."
>
> Male student, cooperative group.

> " The respect increased between the students and the cooperation increased, too."
>
> Male student, cooperative group.

> " Yes, liking the subject was increased. I was afraid to go to the board , but now I don not feel such feeling of fear."
>
> Male student, cooperative group.

No students in the traditional group mentioned any effect on the non-cognitive domain that may be created because of the teaching method, except four female and male students who felt that the teaching method made them proud of themselves because their teachers knew them well as a good students and they mostly took the leading position in the class. Examples of these responses are given below.

> " I don't think so."
>
> Female student, traditional group.
>
> " No."
>
> Male student, traditional group.
>
> " Yes, I pride myself because I solve mathematics and the teacher knows that I'm a good student."
>
> Male student, traditional group.

Interviews with teachers

Teachers' views about their students' activity and other non-academic achievement

- **Did you observe any changes in students' activities, relationships, personalities or attitudes towards mathematics, and their social skills? If yes, is this a new behaviour? Can you explain the reasons? If no, can you also explain the reasons?**

All teachers in the cooperative group commented that there were many advantages of cooperative learning in the non-cognitive domain. They observed new behaviour from the students such as the cooperation between them, the strong relationship, between the group-mates, liking each other and the harmony. Teachers commented that some bad behaviour was decreased, such as meanness, jealousy and selfishness and some good behaviour increased, such as strong personality, dare to challenge the mathematical problems. Moreover, they found that by using cooperative learning it broke the social differences, like colour and social class. Some of these responses are written below.

> " Yes, group learning broke the social differences like colour, and social class and built a harmony between students. For example, there were two students one of them is distinguished on the sports field and the other one is distinguished academically. I observed that there was a very strong harmony between them. The physical one became very interested in maths lessons and the other one became interested in sport. Also, there was a student who was very

> quarrelsome but when he was put in a calm group he became an active and social member."
>
> Male teacher, cooperative group.

> " The relationships became very strong especially in the one group. With respect to personality, the high achieving students became less selfish. With respect to attitude, high achieving students do not pay attention to the cooperative method so much. Intermediate students positively responded to mathematics by applying the cooperative method, low achieving students either increased their attitudes positively toward mathematics or some of them did not take. I hope if the cooperative learning will be started to be used from the basic primary stage. Students will be used to using it and they will gain more advantages to their personality."
>
> Male teacher, cooperative group.

> " Yes, some girls' personality was weak but became strong and they dared to answer. They challenged the mathematical problems. Some girls gained positive attitudes towards mathematics. The cooperation was observed. The meanness and jealousy were gone. The competition between groups was the usual attribute in the class."
>
> Female teacher, cooperative group.

Most teachers in the traditional classes did not observe any changes in students' behaviour or personality. They explained that, because they applied the traditional method, there was no interaction at all between the students and each of them is responsible for himself/herself. One female teacher mentioned that, because she tried to create competition between girls, they made some mathematical activities for the need of the lesson and high achieving students were confident of themselves because she gave them a chance to introduce the lesson to the class as a teacher. Some of these responses are quoted below.

> " No, normal, because we teach by individual method and each student is responsible for herself. There is no interaction between the students. So, none of these changes had been observed or noticed."
>
> Female teacher, traditional group.

> " The status stayed as it was before."
>
> Male teacher, traditional group.

> " Yes because I tried to create competition between them. Some girls made some mathematical activities for the need of the lesson. One of the high achieving students could introduce the whole

lesson as a teacher for the class. It was a new behaviour that made the students confident, like mathematics and the teacher, too."

Female teacher, traditional class.

Summary of findings

Quantitative and qualitative data analysis found that there were many advantages and outcomes because of applying the cooperative method in the non-cognitive domain while none of these outcomes were noticed or observed in the traditional classroom. The advantages were in different aspects: personality, behaviour, attitude and social relations skills. Within the analytical stage, the quantitative and qualitative findings supported each other. One point to be declared here is that, in spite of all of these advantages, the researcher believes that this teaching method does not affect strongly on students' personality, such as self-esteem, internal locus of control, acceptance of mainstreamed academically handicapped students and the last one is for high achieving students who felt that they spent time in helping others and lost the first place in the class. Actually, the researcher has her special philosophy for this issue because changing something in human personality takes a great deal of time and many factors may affect the development of this personality. Moreover, human personality begins to be developed from birth and the most important scholastic stage is the primary basic stage. So, the researcher believes that such outcomes, such as self-esteem and locus of control, may be strongly achieved if cooperative learning is applied for a long time, especially from early elementary stages. Also, other external factors, like relatives playing together, develop these features in students' personality. However, this issue is not a basic one to be discussed in the present research.

8.6 Sixth Issue: The external factors that may affect the learning and teaching process

Assessment of the effect of other external factors that may affect the learning and teaching process

The relationship between the teaching and learning process is a complex one. Many factors bind together to form the students' outcomes either in the cognitive or in the non-cognitive domain. This research concentrates on the effect of the teaching method involved in teaching mathematics on promoting students' mathematical achievement and problem solving skills. As discussed in chapter six, no one can ignore the fact that there are other external factors that may play a role in the teaching and learning process, such as students' ability, teachers' characteristics and teaching skills, motivation, classroom management, sex and gender differences, ethnicity, language, social class and curriculum. Within the analysis stage the researcher used part five of the questionnaire in the quantitative analytical stage and used the field notes within the lesson observations, the interviews with teachers and students to explore how other external factors may affect the teaching and learning process. The following discussion for the quantitative and qualitative analytical stage explores the effect of these factors.

- **The quantitative part**

The questionnaire (part five)

The questionnaire was used for the quantitative part of this issue (see appendix three, part five) to search for other factors that may play a role in the teaching and learning process and assess its effects. Means and standard deviation for this part of the questionnaire were calculated previously (see table (8. 10).

Since there were differences in the means and the standard deviations, multivariate analysis of variance (MANOVA) was used to assess if there were statistically significant differences in the students' responses towards this part of the questionnaire as a dependent variable related to the effect of teaching method, gender and the interaction between teaching method and gender as independent variables (see table 8.11).

Remark: for the effect of the interaction between teaching method and gender see appendix nine(b).

Table 8.11 (with respect to part five of the questionnaire) reveals that

1. There are statistically significant differences related to teaching method. Hence:
    - Hypothesis 22. H0 is rejected.
    - Hypothesis 22. H1 is accepted.

Remark: for hypothesis 22.H0 and 22.H1 see page 144.

Comparing means in table (8.10) indicated that the mean of the total cooperative group was less than the mean of the total traditional group (1.2824 < 1.4571) with statistically significant differences. This means that there were more external factors that may affect the teaching and learning process in the traditional group than in the cooperative group. This supports the findings of the study for the cooperative group since no major effect of the external factors on their outcomes compared with its effects in the traditional group.

2. There are no statistically significant differences related to gender (Sig. 0.273 > 0.05). Hence:
    - Hypothesis 23. H0 is accepted.
    - Hypothesis 23. H1 is rejected.

Remark: for hypothesis 23.H0 and 23.H1 see page 144.

That means that there are no gender differences in the external factors in the female and male groups.

3. There are statistically significant differences in students' responses towards this part of the questionnaire related to the interaction between teaching method and gender (see appendix nine (b)). Hence:
    - Hypothesis 24. H0 is rejected.
    - Hypothesis 24. H1 is accepted.

Remark: for hypothesis 24.H0 and 24.H1 see page 145.

Comparing means in table 7.10 shows these differences. The means of the female cooperative and traditional groups were nearly the same. The mean of the male cooperative group is less than the mean of the male traditional group with statistically significant differences. This illustrates that the external factors play a role in the male traditional group more than in the cooperative group. This supports this study that the major effect on students' outcomes in the cooperative group is related to the teaching method applied in their classes.

For more assessment about some factors that may affect the teaching and learning process, frequencies and percentages for the items of this part (see table 8.16) were calculated and analysed. Moreover, the qualitative data analysis explores the effect of other factors that were not included within this part of the questionnaire as complementary to the quantitative data analysis. The following stage will explain students' responses towards this part of the questionnaire.

Table 8.16 reveals that

1. Items 1, 2, 3, 4 and 5 show that most students do not have a personal computer at their homes. However, more students in the traditional group have a computer than in the cooperative group. There are fewer students who take tutorial mathematical classes and they are mostly in the female cooperative and male traditional groups. However, more of these are students in the traditional group than in the cooperative group. Most students get assistance from their families in learning mathematics, with more percentage in the male group. There are some students who study mathematics from books other than the mathematics textbook, especially in the traditional male group. Actually, this point will be highlighted in the interviews with teachers, where one teacher in the male traditional group mentioned the effect of this point. In addition, few students take mathematics assisting classes in educational centres but most of those are in the male traditional classes.

Table (8.16)

Frequencies and percentage of the students' responses (Yes or No) towards the items of part 5 of the questionnaire

Part five: The external factors which may affect on the learning and teaching process

Item	TM	G	Yes		No	
			Frq.	Per.%	Frq.	Per.%
1. I have a personal computer at home.	C	F	17	20.48	66	79.52
		M	26	30.23	60	69.77
	T	F	27	30.00	63	70.00
		M	23	27.06	62	72.94
2. I take tutorial classes in mathematics.	C	F	10	11.90	74	88.10
		M	6	7.06	79	92.94
	T	F	5	5.56	85	94.44
		M	17	20.00	68	80.00
3. My family helps me in learning mathematics.	C	F	50	59.52	34	40.48
		M	44	51.16	42	48.84
	T	F	49	54.44	41	45.56
		M	63	74.12	22	25.88
4. I study mathematics books other than mathematics textbook.	C	F	21	25.00	63	75.00
		M	20	23.26	66	76.74
	T	F	22	24.44	68	75.56
		M	32	37.65	53	62.35
5. I take mathematics assisting classes in educational centres.	C	F	6	7.23	77	92.77
		M	6	6.98	80	93.02
	T	F	6	6.74	83	93.26
		M	14	16.47	71	83.53
6. I watch the mathematical educational programmes on the TV.	C	F	35	41.67	49	58.33
		M	25	29.07	61	70.93
	T	F	43	47.78	47	52.22
		M	47	55.29	38	44.71
7. I participate in the mathematics activities at school.	C	F	50	59.52	34	40.48
		M	31	36.05	55	63.95
	T	F	44	50.00	44	50.00
		M	60	70.59	25	29.41
8. I look at the mathematics puzzles and try to solve their problems.	C	F	58	69.05	26	30.95
		M	46	53.49	40	46.51
	T	F	52	59.09	36	40.91
		M	57	67.06	28	32.94
9. I get encouragement from my family to increase my achievement.	C	F	46	54.76	38	45.24
		M	48	56.47	37	43.53
	T	F	56	63.64	32	36.36
		M	66	77.65	19	22.35
10. I use the calculator to solve simple calculations.	C	F	16	19.05	68	80.95
		M	35	40.70	51	59.30
	T	F	33	36.67	57	63.33
		M	24	28.24	61	71.76

TM: Teaching method.
G: Gender
C: Cooperative.
T: Traditional.
F: Female.
M: Male

2. Items 6, 7, 8, 9 and 10 show that more students in the female and male traditional classes watched the mathematical educational programmes on the TV than in the cooperative classes, especially in the male traditional group. More than half of the students participate in mathematical activities at schools, except those in the male cooperative group and more participate in the male traditional group. Most students like to deal with mathematical puzzles and try to solve their problems, especially those in the female cooperative group and male traditional group. Female and male traditional students get more encouragement from their parents to increase their achievement than those in the female and male cooperative classes; half of them get such encouragement but less than those in the traditional classes. Students in the two experimental groups do not use calculators to solve simple calculations with more using them in the male cooperative and female traditional groups.

Summary of previous quantitative findings in part five of the questionnaire

Students' responses to this part of the questionnaire indicate that there are not many external factors that may affect their outcomes except the assistance or the encouragement they may get from their parents or dealing with mathematical puzzles or mathematical activities at school. However, the findings illustrate that the effect of these factors in the traditional group is more than in the cooperative group, especially in the male traditional group, with no statistically significant differences in the female group. This, actually, highly supports the previous findings of the study where, although the effect of the external factors is more positive in the traditional group than in the cooperative group, students in the cooperative learning classes make more positive progress in their mathematical achievement and problem-solving skills while students in the traditional classes stay nearly at the same level of mathematical achievement.

The previous factors included in part five of the questionnaire are not the only ones that may affect the teaching and learning process. During the qualitative stage of the analysis, the researcher assessed the effect of other external factors other than the effect of the teaching method.

The Qualitative Part

Within the analytical stage for this part, the researcher assessed the effect of other external factors that might affect on the learning and teaching process. The data related to this issue were collected through the discussion within the interviews with teachers and students and by the field notes reported by the researcher during the lesson observations within the fieldwork. The points to be presented here are the effect or otherwise of the other external factors, such as students' ability, teachers' characteristics and teaching skills, motivation, classroom management, gender differences, ethnicity, language, social class and curriculum

- **Students' ability**

The sample of the study was chosen randomly and, since the classes in Jordanian schools are mixed ability classes, each class involved in the experiment contained a different level of students' ability (low, middle and high achieving students). Actually, at the beginning of the experiment teachers in the two female and male schools commented that the distribution of the students in the classes was usually arranged according to their exam at the end of the scholastic year, where each class should have high, middle and low achieving students. Hence, all classes are mixed ability classes. After applying the pre-test (see table 8.2), the researcher observed that the male cooperative and traditional groups were nearly equivalent while the female cooperative and traditional groups were not equivalent (as mentioned previously). One teacher mentioned this because there was a class in the traditional group that had more high achieving students because they tried to form a standard class in the school to increase the competition between these girls. However, in spite of this fact, the class contains other level of students, too. So, all the classes were mixed ability. A very important issue here is that, since the main objective of the research is to assess the effectiveness of the teaching method in promoting mathematical achievement and problem solving skills before and after the experiment, these non-equivalent classes do not make sense. However, the most important thing is to search for how the teaching method might affect students' achievement according to their levels of ability.

A very interesting finding within the previous stages of the analysis of the views of teachers and students is that the teaching method did not have any effect on high achieving students because they are initially good students in mathematics, they could understand mathematics quickly, they have a chance to participate in the classes, to compete between others and they can solve mathematical problems quickly and they had a chance to be assessed by their teachers at the end of the lesson. Teachers also commented within the interviews that they believe that the major factor which affects these students is the role of their parents or relatives at home. This result gives a good explanation to answer the questions why such students were less enthusiastic to apply cooperative learning. Actually, this is because they felt that this teaching method decreased the opportunities for them to participate in the class most of the time, to give them the first place in the class and, sometimes, they lost the leading position. So, they felt some kind of frustration.

The real effect of the teaching method was on the intermediate and low achieving students. All teachers and students of these abilities interviewed in the cooperative learning classes commented that this teaching method positively enhanced their achievement in mathematics and promoted their problem solving skills. With respect to those students (intermediate and low achieving students) in the traditional group, it was found that the traditional teaching method did not help to enhance students' general achievement in mathematics and affected negatively in promoting problem solving skills, especially in the male group.

The positive effect on students at those levels was that the cooperative method offered them the chance to interact with their group-mates during problem-solving, to cooperate with others, to present several type of solutions, to follow the steps of solving the problem, to understand the concepts and rules, to know when and how to use these concepts and rules in solving problems, to use suitable procedures and algorithms, to speak mathematically and use mathematical vocabulary, to challenge the mathematical problem and give assistance to each other. In brief, to do mathematics by themselves in such a way that it would be difficult to forget what they had done and discovered. This shift created a student-centred learning approach which was the major reason for increasing and developing low and intermediate achieving students' mathematical problem solving skills, where no effect of the traditional teaching methods were measured or observed (especially for low and intermediate achieving students) because this teaching method could not offer a solution to their difficulties and problems in the mathematics classroom. However, all previous evidences indicated that the effect of the teaching method was highly positive for intermediate achieving students in the cooperative group and negative for the male low achieving students in the traditional group.

- **Teachers' characteristics and teaching skills**

This factor is an important one and because of that the researcher paid attention to choosing the sample of teachers to be as equivalent as possible. So, teachers were chosen such that all of them had the same qualifications (bachelor's degree in mathematics) and approximately the same number of years of experience (10-12 years). In spite of this consideration, no one can ignore the fact that teachers who were trained in how to use cooperative learning strategies gained some kind of professional development and added new teaching skills to their teaching experience. The lesson observations conducted within the fieldwork were vital in order to evaluate the general teaching skills for all teachers involved in the experiment to assess to what extent teachers in the cooperative group applied the new teaching method and how well the teachers used the traditional one. However, this point will be discussed in detail in the next stage of the analysis.

In this situation it is important to declare the views of students. All students involved in the experiment who were interviewed were very satisfied with their teachers' skills and ability to teach mathematics and discussed the material in an excellent way. There were satisfied with the ability of their teachers to apply the teaching methods effectively and to explain the difficult problems they may face. Of course, each person has his/her own characteristics and personality and some thing noticed during the fieldwork was that male teachers in the male traditional group had good relationships with their students. One of them broke the barrier between him and his students by making a joke of his control during the class lesson. Another one dealt with his students with high level of honour and appreciation. This explained of students' responses within the interviews to their satisfaction with their teachers' skills within the class. Moreover, this also explained to their positive attitudes toward mathematics although of their weakness in mathematics. Also, it was noticed that one female teacher in the traditional group tried to make some kind of competition between the girls to motivate them in working and break the boredom of the girls and the pressure on the teacher that were felt in their traditional class.

In spite of these teachers' characteristics, the effect of the teaching method was more positive in the cooperative group than in the traditional one. That fact supports the findings of the study where, in spite of these relations, the results were positive in the cooperative classes. This could refer to the situation in the classes where it was student-centred approach in the cooperative classes and teacher-centred approach in the traditional ones. However, the researcher found that all teachers involved in the experiment were qualified academically, their personalities were strong to control their classes and they managed the learning process within their classes.

- **Motivation**

This factor was highlighted as assisting the cooperative method to enhance the learning process. This was because, when teachers had been trained in how to use the cooperative method, they might be strongly motivated by the new method. They might be more enthusiastic in applying the new strategies than those using the traditional approaches. Moreover, students themselves, in the cooperative classes, might also be motivated and more enthusiastic to apply the new teaching method that creates an exciting environment full of competition and interest. Really, it is difficult in such research to ignore this fact and its effect on students' performance where positive effects were expected on the basis of motivation theory, especially when applying cooperative learning which enhances the motivation theory because it focuses primarily on the reward or goal structure under which pupils operate (Slavin, 1990a). However, and in spite of that, it was observed that teachers in the traditional group used to motivate their students by reinforcement. Some of them made a kind of competition on the board to solve problems. All of them used to let students participate in discussion by solving some problems on the board and there was a kind of a reward or an incentive like praise or, at most times, an encouragement by words like; '*well done*' or '*good*' or so on...

The difference observed between the cooperative and the traditional methods is that the cooperative method gave all students a chance to enter to the competition field and motivate all of them to work hard and cooperate in order to win the group reward, while the traditional approach restricts the competition between a limited number of high achieving students only where the motivation was for this standard of student.

- **Classroom management**

Managing the classroom is an initial step towards the more important goals related to cognitive and affective learning. The good teacher who can manage his/her classroom well during the teaching and learning process and solve all problems she/she may face in the class. However, all teachers involved in the experiment had strong personalities to enable them, control and manage their classes. It was noticed during the lesson observations that teachers in the traditional classes were very able to manage their classes by good organisation, controlling the students and keeping the class quiet. However, a very important issue to be addressed here is that using the traditional teaching method in such crowded classes gave less chance for the teacher to manage the learning process well where some students were isolated because of their shyness, depression or negative self-attitude. On the other hand, in spite of such crowded classes and the type of furniture, it was observed that teachers in the cooperative group managed the classes very well physically, with the assistance of students, and managed the cooperative learning process very well in all aspects, as will be discussed in the next stage of the analysis.

- **Gender differences**

The study was conducted in two separated female and male Jordanian primary schools. The effect of gender was one of the independent variables of the study; the other one was the teaching method. The effects of gender and gender differences were considered during all stages of the analysis as well as the effect of the teaching method and, moreover, the effect of the interaction between teaching method and gender. One interesting finding within the analytical stage related to gender differences, is that female students in the two experimental groups achieved more in mathematics than the male group. In spite of that, the attitude of the male group towards mathematics was more positive than the female group.

- **Ethnicity, language, social class and curriculum**

All students involved in the experiment were from Arabic origins with Jordanian nationality, those who speak the Arabic language which is the first language in Jordan. So, there is no affect of these factors on students' outcomes.

Although students might be from different social classes and different parents culture, the researcher did not go in depth into the effect of these factors in order not to stray so far from our major objectives of the research. However, some items used in the questionnaire (part five) deal with kinds of social class where, if students have their own personal computers, or get assistance from their parents, or a tutorial in learning mathematics, that is what we need to know in such research. It was found from a previous analytical stage that other external factors that may affect the teaching and learning process had more effect on the traditional group than on the cooperative group, which supports the positive effect of the cooperative method in the study. Actually, interviews with teachers identified that the effect of the students' social class is important where they observed that most of the high achieving students in their classes related firstly to the effect of their parents or relatives and not really on the effect of the teaching method had on those students' achievement.

The last factor that may affect the teaching and learning process in such research is the curriculum. The mathematics curricula in Jordanian schools are fixed by the Ministry of Education. So, the same topics were taught in the two experimental groups to assess teachers' views about the Jordanian mathematics curriculum and the suitability to use it in different teaching approaches. The question related to this part was:

- **Do you think that our curriculum is presented in a good way such that you can apply any teaching method for this curriculum? If yes, why? If no, what are your suggestions?**

All teachers involved in the experiment commented that the Jordanian mathematics curriculum is not prepared in such a way to assist teachers in using different teaching methods especially cooperative learning which needs good preparation for using group work. Teachers in the cooperative group pointed out that the curricula are very poor for different activities and worksheets that may be used in cooperative work. All teachers in the two experimental groups commented that the amount of the mathematics material in the curriculum is very large with many mathematics subjects that do not suit the available time and the number of the weekly lessons to finish all these subjects. Some teachers interviewed also pointed out that there are many theories that take much time to be proved without any results. They added that the types of the questions are knowledge and not analytical ones. The most important thing teachers highlighted is the need to prepare the curriculum in a way that gives the teachers a chance to adapt the lesson for the use of any teaching method, especially if it is the cooperative one which needs a special curriculum developed by a specialist in that field. Teachers pointed to the need for more resources (other than the textbook) and educational technology (for example, the computer) for the teacher and the students to interact the international development in the educational field. Some of these responses are quoted below.

> " Of course not, and it is not prepared well to serve any educational teaching method. So, what about the cooperative method that needs a special curriculum prepared by specialists in that field and a training programme for the use of such method! Moreover, the curriculum needs to decrease the contents of the material, delete the theories that take a lot of time to prove without any benefits. There must be a shift to use new educational technology like the computer in maths education because I have noticed that a lot of low achieving students can use the computer very well."
>
> Male teacher, cooperative group.

> " I suggest introducing the textbook in such a way to let students pay attention to it by colours, pictures and highlight the basic and important things. Several forms of worksheets and activities are prepared especially for the need of the cooperative work."
>
> Female teacher, cooperative group.

> " Actually, the time available for us and the number of the weekly lessons are not suitable for us to finish the mathematics material in the curriculum. The contents of the material is large compared with time available especially in grade eight and nine. Moreover, most of the exercises are knowledge and there are few analytical ones."
>
> Male teacher, traditional group.

Actually, during the interviews with teachers to evaluate the training programme, all cooperative teachers pointed to the importance of the assistance that the researcher provided them in the training programme by introducing several types of worksheets and activities in different types of mathematics lessons to train teachers how to adapt the Jordanian mathematics curriculum to the needs of cooperative mathematical learning.

Summary of findings

Previous investigations illustrated why it was very important in this present study to assess the effect of the external factors that may play a role in the teaching and learning process where several findings had been raised regarding these factors. The quantitative data analysis indicated that there was no basic effect for factors that had been tested quantitatively. However, it was found that these factors had more impact on the traditional group than the cooperative one which supports the findings of the study.

The qualitative part comes as a complementary one to assess the effect of other factors that give different indications in the analytical stage. Students' responses differ towards teaching methods regarding their ability and teachers' characteristics play a role and affect students' perspectives. The teaching skills differ in the two experimental groups which may relate to the teaching method applied in these classes. Gender differences had been raised through different stages of the analysis. The curriculum was a very important factor to assess to what extent it can be used for cooperative learning and how it is possible to be developed. On the other hand, the type of the mathematics material in these curricula indicated more or less effectiveness of the use of cooperative learning.

8.7 Seventh issue: Evaluating the training programme and the teachers' response

Applying cooperative learning strategies in the mathematics classroom requires good preparation and a specific course of training for teachers in how to use such strategies because this teaching method requires different approaches to planning and teaching than the other traditional methods of instruction. So, teachers involved in the experiment were trained in how to implement the new teaching method in their mathematics classes to support them with the best framework for effective implementation. The training programme concentrated on providing teachers with a good definition for cooperative learning to understand it well and to believe in its value. Moreover, it supported them with a good explanation about the principal components of cooperative learning, when to use cooperative learning in the mathematics classroom, the teacher's role and decisions, how to start it in implementation, how to teach a cooperative learning problem-solving lesson and how to adapt a mathematics lesson for the use of cooperative learning groups. Actually, all of these points were mentioned in detail in chapters five and seven of this study.

Within the analytical stage for this issue, the researcher evaluated the training programme of the views of the teachers to assess its advantages and disadvantages for the purpose of improving and developing such training programmes in the future and to assess how teachers can best be trained to use the cooperative learning. Moreover, within the analytical stage the researcher also examined to what extent teachers who were trained applied the training programme.

Data collected within interviews with teachers and used for evaluating part of the training programme and lesson observations that were conducted by the researcher herself during the fieldwork were used for evaluating teachers' responses towards the training programme.

Interviews with teachers

- **How confident are you of the understanding you feel as a teacher to use effectively the cooperative methods as a teaching method?**

All teachers involved in the experiment who were trained and applied cooperative learning commented that they were satisfied with their ability to apply the cooperative teaching method effectively. They were very confident of their real understanding of what is meant by cooperative learning, what are the objectives and values and how to implement it in the mathematics classroom, except one male teacher who felt that, in spite of his understanding in how to use it as a teaching method, he pointed out that applying such a teaching method in an affective way needs longer time because practicing such a teaching method for a long time gives the teacher the ability to understand more the real meaning of the cooperative method and, hence, this will reflect on his ability in application. Some of these responses are given below.

> " To the farthest extent that is because I felt that the training programme covered most of the problems that we might face in implementation which asists us to understand the real meaning of cooperative learning well and apply it effectively."
>
> Female teacher, cooperative group.

> " So far, because of feeling comfortable to apply this teaching method and because of the assistance that we got during the training course and especially at the beginning of the experiment when we applied the experimental implementation".
>
> Male teacher, cooperative group.

> " Theoretically, I feel that I understand it 100 % but I still feel that to apply it effectively 100% too needs more time than that because as far as the teacher applies this teaching method, the practice will give him more understanding of the teaching method. This will reflect on his ability to apply it more effectively."
>
> Male teacher, cooperative group.

In order to assess other teachers beliefs about their ability to apply cooperative learning, the researcher explored the views of the teachers in the traditional group. Most teachers (3 out of four) who were not trained in how to use cooperative learning strategies agreed unanimously that they could not apply such a teaching method because they had not taken any training course for this teaching method. Moreover, they felt that this teaching method needs good preparation and a special course of training in order to be applied effectively. One male teacher pointed out that, sometimes, the supervisors asked them to apply such a teaching method. He added, in spite of that, he preferred not to apply it because he had not take any special training course and he just had a simple idea about it. Moreover, he commented that the idea of using cooperative learning had been introduced in a previous training programme he had undertaken in applying the new mathematical curriculum as one of the teaching methods which can be used. Actually, all teachers involved in the experiment took the same in-service training course that this teacher mentioned; this was explored during the next question of the interviews. Some of these responses are written below.

> " No, because I didn't take any training course in cooperative learning and I did not try to apply it. I think that this teaching method needs good preparation to apply it."
>
> Female teacher, traditional group.

> " I don't think so. To apply such a teaching method effectively, there should be many arrangements and special programmes. Actually, we don't have a very good idea about it. "
>
> Male teacher, traditional group.

- **Are you satisfied with the training programme you had in how to use cooperative learning in the mathematics classroom? What are the advantages and disadvantages of the training programme?**

An evaluation of teachers' views of the training programme identified that they were very satisfied with the training programme because of the advantages that gave them a good framework and a solid basis to establish effective implementation in the mathematics classroom. They commented that the training programme was very comprehensive and treated many problems which might be faced in applying such a teaching method. The contents of the syllabus that was prepared and distributed for all teachers also presented in detail all information and strategies they used in the implementation. Moreover, the discussion during the training course was very useful and highlighted different ideas of the views of both the teachers and the researcher. The most important thing they mentioned is that the most useful technique in the training programme was applying an experimental implementation in the classes because it was a vital practice in how to apply cooperative learning strategies in the mathematics classroom. Also, they were very pleased and highlighted that preparing examples of the mathematics worksheets and activities explains to teachers how to adapt mathematical lessons in the Jordanian curriculum for the use of group work, providing teachers with new ideas and techniques helping them in the implementation because the present curriculum are very poor and cannot serve such a teaching method. All teachers highlighted that, without such a training programme, it was difficult for them to know in depth what are the basic components of cooperative learning and what are the strategies they should follow in implementation to achieve these components in such a way to apply an effective implementation and to gain a positive outcome. One teacher commented that the training programme was cooperative and competitive in its content and added new techniques to their teaching experiences. On the other hand, teachers mentioned that they felt that it would be better if the training course was longer. One teacher felt that there was a sudden change in the teaching method for students without enough previous experience. The last teacher did not mention any disadvantages in the training programme. Some of these responses are quoted below.

" I was so satisfied because it gave us a real meaning to what is meant by the cooperative method, it treated a lot of questions and problems that we might face during the implementation and the content of the syllabus was marvellous to declare in how to apply this teaching method effectively... I think the time was not quite long enough."

Male teacher, cooperative group.

"Actually, good preparation for the training programme was really comprehensive and included every thing that the teacher might face even in preparing examples of the worksheets and activities because we have no resources for that. The discussion was very useful to share our ideas with yours. The wonderful content of the syllabus gave us a deep understanding of the components of cooperative learning and how to implement it effectively. The best thing was the experimental implementation which was realistic."

Female teacher, cooperative group.

" Actually, it was cooperative and competitive in its content and added new techniques to our previously experiences... I think the disadvantage was by suddenly changing the teaching method for students without enough experience."

Male teacher, cooperative group.

- **Would you prefer to take an extra training course in teaching strategies in mathematics? Why?**

Teachers in the cooperative group commented that they would prefer to take extra training courses in teaching strategies in mathematics to add new experiences and teaching skills. They felt that, without the training programme they had, it was difficult for them to apply the new teaching method effectively. Most of them highlighted the point that it is better to have training courses for new and modern teaching methods because they face many problems in teaching mathematics and they feel that some new teaching method may solve most of the problems they face as they have found in the cooperative one. Also, teachers in the traditional classes hoped to take training courses in mathematical teaching methods to give and receive benefits in such courses and to develop the teaching and learning process in the mathematics classroom. Actually, all teachers involved in the experiment mentioned that they took an in-service training course for the new mathematics curriculum for the basic primary stage that concentrated on the content of the curriculum but not on the teaching methods and strategies. Some of these responses are given below.

" Yes of course, to add new experiences that may solve a lot of problems we face in the teaching of mathematics."

Male teacher, traditional group.

" Yes, to give and receive benefits but with a condition that it must be new and modern teaching strategies like cooperative learning as an example which I noticed made a positive change in the teaching and learning process."

Female teacher, cooperative group.

" Yes, why not? To enhance my teaching style and develop the teaching and learning process."

Female teacher, traditional group.

" Actually, without the training course it is difficult to master well how to apply the teaching method especially if it is a new one."

Male teacher, cooperative group.

Evaluating teachers' responses towards the training programme and to what extent they applied it during the implementation of the experiment

For this purpose, the researcher prepared an observation sheet (appendix four) for the purpose of lesson observations within the implementation of the experiment. It was observed that there was a big gap for both teachers and students in implementing cooperative learning between the beginning and end of the experiment and it was positive progress during the experiment. However, it was observed that all teachers in the cooperative group applied good implementation. They satisfied most of the principal components that should be applied for an effective implementation. Moreover, it was observed that few elements were not achieved although they were mentioned during the training programme. The following discussion presents in detail teachers' responses towards the training programme and to what extent they applied it during the implementation of the experiment.

The cooperative classes highly achieved most components that satisfied their objectives in instruction and guaranteed effective implementation. Teachers were aware of their roles and decisions in the implementation. Since classes involved in the experiment were big ones, which is the usual case in most Jordanian schools, teachers assigned students to heterogeneous groups that consist of six students, except one male teacher who prefered to use groups of four to minimise the troubles that were raised because of arranging the classroom physically and moving desks for the purpose of group work. All groups were mixed ability classes containing high, middle, and low achieving students. At the same time, teachers took care to divide the students according to their behaviour and their communication skills to avoid any disturbance which might occur.

In spite of the large number of students in the classes, it was observed that the classes were well arranged in such a way that it was very easy for teachers to move and integrate from group to group during the exploration stage and group work. Actually, the area of the classes and students' assistance (especially in the female group) helped teachers with good organisation of the classroom for the use of group work.

The cooperative lessons involved within the experiment made a big shift by transferring the role from teachers' role to students' role which progressed within the passage of time. It was noticed that nearly 80 % of the lesson was for group work which gave the students a chance to cooperate and to interact in the mathematics lessons. Actually, teachers involved in the experiment were well qualified and they were able to introduce the mathematics lesson in a good way and manage the teaching and learning situation effectively.

When teachers were asked in the interviews about the teaching strategies they used in the mathematics lessons **(What are the teaching strategies you used in the teaching of mathematics?)** they commented that they used the exposition and illustration techniques in introducing the new mathematics lessons, explaining to students the academic task to be solved and introducing simple examples. Most strategies relied on exploration moves, which concentrated on the students' role. The last stage was the evaluation stage providing feedback by discussion techniques. Actually, it was noticed that the cooperative method gave teachers and students a chance to use different strategies in the teaching and learning situation of the mathematics lessons within the cooperative group that engaged the group members in brainstorming, especially in problem-solving lessons. In addition, it was noticed that this teaching method increased the opportunities for teachers to use learning by discovery strategies especially in the developmental lessons and when students were expected to generalise a mathematical fact or rule.

Teachers in the cooperative group introduced the new lesson in about ten minutes (20 % of the time of the lesson) to explain the objectives of the lesson, present the new concepts and present simpler and easier problems than the ones which students were expected to solve to ensure that students understood the basic steps in solving problems. The next part was for exploration and group-work. Actually, it was noticed that teachers in the female and male groups were very aware and careful to monitor the group work and encourage students to help each other, observing and listening to students' discussion, moving from group to group and giving students assistance if all group members need help. In spite of the good control in the group work of the two female and male groups, the researcher noticed that all students in the female group were more cooperative and responsive to master the material than the male group where there was a limited number of students who did not care about the mathematics lessons.

The most interesting thing was that students in the female group prepared, as the teacher asked them, a bulletin board that contained the names of the groups. At the end of every week the group which made more progress according to the group average score took the recognition and the name of this group was written on the bulletin board to be advertised for the whole class. No problems were observed or mentioned by teachers from the female group, such as complaining of the difficulty in arranging the desks or any disturbance which might occur. The situation was quite different in the male group where teachers prefered to recognise the master group by additional marks or teachers' incentives because teachers in the male group felt that male students did not take care to others recognise (for example, advertising the group's name on the bulletin board) and they felt that the teachers' esteem was more important.

Actually, at the beginning of the experiment male teachers pointed out the difficulty in arranging the desks, but after a period of time every thing was alright. Two female students refused to apply the cooperative method and they asked their teacher to allow them to sit at their individual desks. After just two lessons the two girls asked their teacher to allow them to enter the group work and they were very active members from then on. The researcher found that applying the new teaching method led to some problems at the beginning. This may be because it was a new method that students were not used to which might cause some kind of confusion for some of them at the beginning of the experiment, but, after a period of time and after students felt interested within their group work, all of the problems disappeared and a new cooperative atmosphere was noticed.

Teachers in the cooperative classes managed the groups very well. They explained to students that it was important to cooperate with each other to achieve their goals as a group; at the same time, each student ought to be responsible to contribute and master the material and understand that they are individually accountable for the assignments. Actually, most of basic components were achieved: the group goal, since the incentives and recognition focused in the group reward; individual accountability by applying the quizzes and monthly exams where each student is responsible for him/her self; the team competition that arose during the implementation especially, in the female bulletin board; task specialisation, by assigning students specific tasks where students had different roles during the group work on the worksheet and activities especially in the developmental lesson.

Some components were very poor in the cooperative classes, such as adapting to individual needs and giving equal opportunities for success. It was observed that there was no competition between students of the same standards in the groups to achieve such goals. Teachers commented for this issue that they did not have enough time to do these things. Any way, the implementation was good and the researcher felt that, if there were more facilities available, the implementation would be more affective and more successful.

Teachers in the cooperative group were anxious to ensure that students were positively interdependent. It was also observed that the interaction and cooperation between the group members was at a high level to complete the learning task. They are linked with each other because they had a common goal and would like to get the group reward. Actually, this positive interdependence had been achieved by most students except for limited number of low achieving students especially in the male group.

The competition between groups created a wonderful environment that encouraged students in each group to cooperate and master the material. The attitudes of the students were more positive towards this teaching method especially after applying it for a period of time.

One important thing observed was that cooperative learning gave teachers a chance to follow all students within the groups, present their solutions, evaluate and give them feed back after evaluation. The classroom discussion was nearly at the end of the lesson, after the exploration and group work had finished, to evaluate solutions and present students' answers. The classrooms were so well arranged, especially in the female group that the researcher felt that the class even wanted to talk and said they were ready for cooperative work.

Teachers used the blackboard for discussion, the textbook, worksheets and activities for the group work, weekly quizzes and periodical exams. Sometimes, simple materials that were easily available were used and students could help by bringing some material. Teachers commented that they never used new educational technology because there was none available.

Actually, the researcher was satisfied with the teachers' response in applying the cooperative method, especially with the available resources and facilities and the limited time to allow both teachers and students to develop their skills in implementing such a new teaching method.

In fact, the researcher believes that cooperative learning divided the work for both teachers and students in order to let each of them do the work that he/she is responsible for. This teaching method offered a solution for many difficulties that the mathematics teacher faced in such crowded classes and helped him/her to manage the teaching and learning process in such a way to develop students' achievement and skills. On the other hand, the environment in those classes was full of cooperative work within the groups. Most students participated, interacted and worked at mathematics by themselves, solved mathematical problems, helped others and exchanged benefits. Actually, in the cooperative learning strategies students engaged in brainstorming through problem solving and guided themselves to learn by discovery in the developmental lessons which increased their mathematical achievement and developed their problem solving skills.

Summary of findings

Previous investigations illustrated that teachers in the cooperative groups were satisfied with the effectiveness of the training programme conducted to provide them with a basic framework for implementing the new method effectively and they were confident in their ability to apply cooperative learning. Moreover, they highlighted the need of such training programmes in the career field to develop their skills in teaching mathematics by using new teaching methods. Teachers commented that the training programme was comprehensive in theory and practice. The content of the syllabus and the discussion involved through the training programme were very useful. Moreover, applying an experimental implementation at the beginning of the experiment in classes was so important to practice the new method on the real ground. The worksheets and activities provided for teachers were helpful for them in how to adapt mathematics lessons in the Jordanian curriculum for the use of group work, where the curriculum was poor in such examples; the lack in resources in that field supported the need for such examples and activities. Teachers mentioned that it would be better if the training programme was longer. There was a sudden change for students by applying the new method without enough experience. Therefore, the first period of time in implementing the experiment was tantamount to a training period for students to develop their skills in how to work cooperatively.

Evaluating teachers' response towards the training programme indicated that it was satisfactory in spite of the available resources and the limited time for implementation. Most of the basic components in applying cooperative learning were satisfied. The teaching and learning process in the cooperative classes could be described as student-centred approach which engaged the group members in brainstorming especially in solving problems and learning by discovery in the developmental lessons. This situation enabled the teachers to conduct good classroom management in such a way to develop students' achievement and skills.

8.8 Eighth issue: Evaluating the teaching skills in the traditional classrooms and how well the teachers in the traditional classroom apply the teaching method

Lesson observations were conducted in the traditional classes within the duration of the experiment to evaluate the general teaching skills teachers applied and how well they applied the teaching method. When teachers had been asked within the interviews about the teaching strategies they applied **(What are the teaching strategies you used in the teaching of mathematics?)** all of them pointed out that they used the lecturing and expository techniques in introducing the new mathematics lesson and after that they used the technique of asking questions during the stage of discussion to encourage students to participate in the mathematics classroom lesson. They added that they rarely, or even never, used the exploration way or learning by discovery because the classroom situation, the quality of students and the time available for them, did not encourage such teaching and learning techniques to be applied effectively. However, the following explanation that had been explored within the observation lessons by the researcher described in detail the teaching strategies involved in such classes and the teachers' moves and techniques in the traditional classrooms.

It was observed that, in the traditional classes, most of the time of the lesson was concentrated on the teachers' role (80 % of the lesson) in introducing the lesson and moving to the discussion mode by asking questions to enrich the classroom discussion which is opposite to the situation in the cooperative classes. Teachers in the traditional classes used the lecturing method to introduce the new material and explain the steps and algorithms used in solving the problems. This role concentrated on the teacher alone. Sometimes, related to the type of the lesson, teachers used to present the mathematical figures as graphs on the board that related to the material of the lesson. In this stage the teacher is the giver and students just the receivers.

After that, teachers move to the discussion stage by asking questions and enrich the discussion by allowing students to participate in solving problems on the board and informing of all the class. Actually, it was observed that participation in all traditional classes was limited and focused on high achieving students who always take the first place in the class in participation, competition between others and gaining teachers' reward or respect. No role was observed for most students in such classes from beginning to end of the lesson. Even then the researcher felt that the students, especially those at the lower end of the class, were just copying and sometimes they might not make any response in the lesson at all. The situation here is converse to the one in the cooperative classes where all students had a chance to cooperate, interact and participate in the mathematics lessons.

The final stage was evaluation which was very poor and did not achieve its objectives. Within this stage, teachers were not able to follow, evaluate or assess all students in the class when teachers gave them some exercises and problems to solved. The limited number who did finish and get the teachers' evaluation and feedback were mostly the same students who used to participate (those how were usually high achieving students). Teachers had no chance to deal with the students' weaknesses especially the low achieving students. The only chance for teachers was to solve most or even all the questions and problems on the board as a feed back for students to give them the answers to the questions. This was not a suitable solution where the role for students was just to copy what was written on the board.

It was not observed that teachers in the traditional classes directed the students to learn by discovery or exploration which concentrates on the students' role, which is converse to the learning situation in the cooperative learning classes which concentrates on the students' role.

In fact, the researcher noticed that, although the traditional teaching method did not give teachers a chance to manage the teaching and learning process well, they were well qualified academically. The discussion was wonderful and the weakness was because of the teaching method itself and was not related to the teachers' abilities.

The classrooms were well organised and controlled by teachers. The blackboard and the textbook were the only instruments used in the lessons. Good relations between students and teachers were noticed, especially in the male group.

Summary of findings

Teachers in the traditional classes were qualified academically and their students were satisfied with their ability in teaching. In spite of that, the teaching and learning process in their classes could be described as a teacher-centred approach where most of the time is concentrated on the teachers' role. This situation did not allow students to practice doing mathematics by themselves and did not allow teachers a chance to evaluate students and give them feed back. Most teaching strategies applied in the traditional classes concentrate on lecturing and expository techniques in introducing the lesson where information is presented didactically by teachers. Then, the teacher moves to the exploration stage by asking questions to enrich the discussion. The situation in the traditional classroom did not allow all students the chance to participate; limited participation was noticed for high achieving students and, sometimes, for intermediate achieving ones. The classes were well organised and controlled by teachers. The discussion was at a high level. There were competitions and incentives in such classes but the participation was mostly by high achieving students. The differences in the teaching and learning process had been observed in both the cooperative and traditional classes.

8.9 Ninth issue: Evaluating the general developmental progress of students involved in the experiment.

The following discussion explores in what ways the cooperative learning might contribute to the broader development of students. Interviews with teachers in the previous analytical stages explored this issue. For more detail and explanation, the analysis of the diaries (see appendix five) that were reported by teachers within the duration of the experiment gave a deep look into the general development observed by students involved in the experiment in different stages with different mathematical subjects.

Teachers pointed out that time played a role when observing the development of students and sometimes the type of the mathematical subject played an obvious role emphasising a positive or negative effect due to applying the cooperative method. The contents of the Jordanian mathematics curriculum that were covered in the first semester of the experiment were linear equation systems, trigonometric ratio for angles and probability (Ministry of Education- Jordan, 1994). In the second semester, the units covered were analytical geometry, factorising, the circle and inequalities (Ministry of Education- Jordan, 1996).

The implementation started near the beginning of the unit of linear equation systems. The content of this unit was covered within four weeks. The first week was the difficult one in the implementation because applying the new method made a big change within the classroom environment. A few students refused to apply cooperative learning and preferred to keep to the usual traditional methods, especially high achieving students. Dividing the students into their groups, explaining to them how they should contribute in applying the teaching method and what their roles were in the implementation took a period of time to let students understand this role and how to cooperate with each other. Students' responses were different from one to another. Some of them were more enthusiastic to apply the new teaching method and others refused to apply it. Teachers reported that, fortunately, the content of this unit encouraged the students to feel interested in the subject because it was easy for the teachers to encourage students to cooperate where most lessons could be successfully taught by using cooperative strategies. The objectives of that unit concentrated on representing the linear equation diagrammatic and solving the linear equation diagrammatically by substitution and by deletion. Problem solving related, basically, to the previous contents and most of those problems were applications and word problems.

Cooperative learning within this unit helped students to master the basic objectives of this unit especially in drawing equations diagrammatically, where students were very interested to do such activities in graphs and determine the solution of the linear equation on the diagram. Teachers also added that the contents of this subject gave them a chance to prepare effective worksheets for use in group work that were difficult to be applied in traditional classes.

The contribution of, and the interaction between, students in their groups were not of a high level at the beginning of the experiment but, as the time passed, and because of the teachers' encouragement for students to interact, the communication skills between students were increased and the development of their positive interdependence was noticed. Actually, teachers highlighted that two basic factors in cooperative learning enhanced the positive interdependence between students, those were the group reward and, secondly, because students well understand that they are individually accountable.

At the beginning of the experiment the cooperation between students was not at a high level especially because the high achieving students felt that they might waste their time in helping low achieving students. Actually, the researcher found that the real cause of such frustration that high achieving students felt (which is investigated through the interviews) was because they missed the high level of the competition between other high achieving students. This is because the situation in the cooperative classes was transferred from the competitive atmosphere between students (especially for high achieving ones) into the cooperation one between the group members in each group to compete other groups. Actually, to avoid such frustration the researcher pointed out within the training programme, to the need to adapt the individual needs by applying competition between members of different teams according to their level of achievement. Perhaps if such competition between high achieving students in different teams was applied, a different response of these students might been observed. However, teachers observed that the interaction and the cooperation progressed after a period of time, since high achieving students began to accept the new situation.

Because low and middle achieving students were so pleased to apply cooperative learning, with respect to the mathematical objectives for this unit, it was observed that cooperative learning enriched students' mathematical knowledge to master understanding the concepts of, for example, the linear equation and the solution of the linear equation, and allowed them to distinguish between different ways of solving problems. In addition, it enhanced other skills, such as drawing, to represent the linear equations diagrammatically and solve simple equations and direct questions. On the other hand, solving word problems and applications was not achieved well within this unit; students were weak in understanding how to transfer word problems into mathematical ones. It was also observed that most students who participated in solving such questions were high achieving students.

The interest in working was noticed, especially in working cooperatively on the worksheets. No activities had been observed within this stage. The social relations were acceptable in the female group but some careless students in the male group tried to make a disturbance in their groups where the teachers were compelled to make some changes in the members of the group. The competitive atmosphere was noticed and new positive attitudes toward the mathematics lessons had been observed from low and average achieving students. Actually, it was observed that the first stage of applying cooperative learning was tantamount to a training period for students to implement group learning.

The next unit was the trigonometric ratio for angles. It was covered within three weeks. The concepts of this unit were new ones to the students because it was taught for the first time. Students' interaction and cooperation were progressed within this unit because it concentrated on understanding the basic concepts of the trigonometric functions with direct applications.

The cooperative strategies within this stage helped low achieving students to get benefits from high achieving ones, especially in applying Pythagoras' theorem and mastering the skills in using this theory in the application of the unit. Actually, this theory was taught previously but it was observed that the cooperative group developed students' skills to use this theory and, moreover, to expect the solution. One interesting thing was observed: one student in his group formed a table for his group including sets of whole numbers which form the sides of right-angled triangles are related by a pattern. It was also observed that the computation skills were developed for most students. Moreover, learning within groups developed students' ability to use the trigonometric tables faster and more accurately. Teachers pointed out that group work was marvellous in such lessons because it was very easy to provide each group with a trigonometric table and, hence, all students could follow up the steps in how to use it. It was difficult for teachers in the traditional groups to present such tables in front of all the class and ensure that those students mastered the use of it. Applying cooperative learning strategies also developed students' skills to solve the right-angled triangles by finding out their sides and angles. Most students well understood the concepts of this unit and they were of a high level of interaction and participation within the classroom group work. Problem solving was at the end of this unit as an application to the previous concepts, rules and algorithms that students learned. It was observed that learning cooperatively encouraged students to solve such problems that concentrated on word problems and real daily life applications.

The cooperation between groups was noticed especially from middle and low achieving students where teachers in the female group commented that it was the first time that they felt that those types of students began to challenge the problems, participate in reading the problem, draw the figures, determine the given information and understand the problem.

The interest was observed especially in the female group, where the motivation when working in groups was at a high level of cooperation between each group member and competitive between groups. Good relations were built between group-mates in the two female and male groups and new students began to participate and interact in the mathematics lessons.

The high level of cooperation with positive interdependence was observed in the final unit of the first semester, which was probability. Students were very motivated in that unit where there were many vital activities which took the form of games and puzzles. Students' activity was observed at a high standard and with positive attitudes towards mathematics and a feeling of interest and excitement in the mathematics classroom motivating students to cooperate and interact between each other. Students' activities were observed. Many students participated in bringing different materials and games for use in the lesson activities, like coins, fair dice and coloured cards.

Teachers noticed that most of the basic objectives in this unit were achieved. Students tasted the benefits of mathematical knowledge and how to use it in practical applications in daily life situations. The interest in working mathematically, like puzzles and games, enriched the atmosphere with comfort and pleasure. Within this unit students spoke mathematically well and used new mathematical vocabulary although it was the first time for students to use such mathematical terms. Moreover, they mastered others skills like, drawing tables, tree-diagrams and using vin-diagrams.

The content of this unit was so easy to teach by using cooperative learning and it was very easy for teachers to adapt the mathematics lessons for the purpose of cooperative learning. However, it was observed that the side discussion between students in working for those activities took more time than was expected to cover the material which forced some teachers to give more than two or three additional lessons in order to finish all the material.

The development was also observed in students' behaviour and personality. Students began to pay more attention to the mathematics lessons by preparing material, solving homework and contributing in out-of-class activities, such as preparing mathematical educational aids and instructional material. Some bad habits decreased, like meanness, jealousy and selfishness and good habits increased, like cooperation, altruism, harmony and strong personality.

In the second semester it was easier for both teachers and students to continue the implementation by using cooperative learning. The mathematical subjects were covered were the following units: analytical geometry, factorising, the circle and inequalities.

It was observed that the cooperative learning strategies in the first unit (analytical geometry) allowed students to develop their skills in using mathematical rules and laws in computing the distance between two points on the straight line, determining the midpoint between them, finding out the slope of the straight line and writing down the equation of the straight line. Cooperation between students was needed to increase their skills in computation and link the material with previously taught subjects. Since it was difficult for teachers to review all the previous mathematical information, low and middle achieving students could get benefit and help from high achieving students as a resource to remember previous mathematical knowledge.

The cooperation was less than expected because some applications and problem solving needed a high-level of thinking and mathematical proofs which showed that most students were very weak in such mathematical skills. However, at the end of this unit, students were participating more actively in lessons dealing with transformation geometry: reflection, symmetry and transition.

Analysing the algebraic expressions was the main content of the second unit. Although teachers used to have difficulties in teaching students how to use different procedures and algorithms and how to choose suitable ones, those in the cooperative group noticed that students got more benefits from their peers by practicing such skills. This encouraged cooperation between students to regain previous information (where it was not new for them) that was needed to develop students' skills in factorisation. The content of this unit concentrated on computation and using different methods in factorising algebraic expressions. It was the longest unit covered within this semester because of its importance and because it was considered a basic one for the next grades. Several mathematical operations were taught which related to factorisation, such as finding out the least common multiple and the greatest common factor, adding and subtracting the algebraic fractions. The cooperative learning groups enhanced the development of computational skills and the ability to choose suitable methods in solving such problems.

The next unit covered within the experiment was the circle. Teachers commented that students usually hated this subject because it concentrated on geometric theories and proofs. Teachers in the cooperative group commented that the cooperative method was useful in enabling students to understand the concepts in this unit: the definition of the centre, the radius, the diameter, the chord, the arc, the angle at the centre and the angle of the circumference and the relationship between them. However, different theories were taught, including the statement of the theory, its proof and its applications. It was noticed that cooperative learning was successful and effective in enabling students to understand the theorem and how to apply it in direct questions. But, this teaching method was not sufficient and effective (especially in the male group) in promoting students' mathematical proofs ability which require more discussion and explanation from the teacher to simplify the steps needing to be taken. Teachers in the male group observed that it was difficult even for high achieving students to do such mathematical proofs and, hence, to help others to understand them.

The last unit was inequalities which was easier than the previous ones. Teachers noticed that students were more cooperative and the previous high level of interaction returned and increased within the content of this unit. The subject itself was effective in implementing the cooperative learning strategies since several mathematical skills were developed, like the ability to solve inequalities, discover the effect of different arithmetic on the inequalities, solve the linear inequalities with one variable and two variables and, finally, solve problems by using the linear inequalities with two variables.

In summary, the general developmental progress of students involved in the experiment was noticed and in different indicators. The progress was not restricted to the mathematical achievement only but it was extended to include several forms. The development of the students was noticed in their general mathematical achievement and problem solving skills because cooperative learning strategies enrich the learning situation and develop students' practice to speak mathematically and use new mathematical vocabulary, deal with mathematical symbols, understand the concepts and rules, use procedures and algorithms in solving problems, link previous mathematical subjects, use different methods in solving problems, evaluate solutions and apply these skills to solve non-routine problems and applications. However, it was also noticed that, in spite of such development, cooperative strategies were less effective and were not sufficient to reduce the problems those students faced in the mathematical subjects which deal with mathematical proofs. Previous indicators identified that the type of mathematical subject played an obvious role emphasising a positive or negative effect due to applying the cooperative method. The interest and benefit was at a high level in lessons dealing with graphs, diagrams, drawing figures, games, puzzles and tables.

Teachers reported that the progress was most noticeable for intermediate achieving students and some low achieving students. However, despite the development observed, students did not master the ability to solve problems well to say that they became problem solvers but, teachers could note the progress and the development, where as it was difficult to get such results in the traditional classes.

One important outcome was that cooperative learning developed other kind of skills, such as writing and reading skills, computational skills, social skills and critical thinking. Moreover, it improved the inter-group relationships, the participation and the cooperation. It also enriched the atmosphere of interest that built positive attitudes towards mathematics. New behaviour features were observed, such as the altruism, liking classmates, good relationships especially between group-mates and decreasing bad habits, like meanness and jealousy. High achieving students were less satisfied with applying this teaching method which indicated that the quality of students and their ability reflected different responses towards applying this teaching method.

Cooperation was not only a feature of students in the cooperative group but it was a feature of teachers, as well. Actually, teachers in the traditional group frequently commented in their diaries that they observed that achieving the mathematical objectives depended on the students' academic ability and no real progress had been observed. The participation was mostly by high achieving students. The type of the mathematics lesson played a role in temporary progress for middle achieving students which were observed in simple lessons and in solving direct questions. However, it was observed that the general weakness was in problem solving and in mathematical proofs. No other development was observed in the level of interaction and social relationships between students but the relationship between them was good. A high level of competition and participation was noticed between high achieving students. New, positive attitudes were noticed towards mathematics lessons in the male group. This is because good relationship was built between students and teachers. Some kind of self esteem and strong personality was noted in the female and male group through the competitive atmosphere which gave some students a chance to be recognised in front of the whole class and gain the teachers' respect. The competition in the female group pushed some girls to participate in some mathematical activities.

Summary of findings

General developmental progress had been observed for students in the cooperative group in different fields. Time played a role in this development where the progress was increased within the period of the time. On the other hand, the type of mathematical material and feature of the mathematics lesson were factors for increasing or decreasing students' interaction within the group and, hence, applying cooperative work more or less successfully. However, it was observed that this teaching method was effective in most mathematics lessons. Students' progress had been observed in different cognitive, affective, social, motivational and behavioural domains. Several mathematical skills had been improved. All of this developmental progress had its effect in enhancing students' achievement in mathematics and promoting their skills in solving problems. Positive attitudes towards mathematics lessons were built. Good relationships between students had been observed. Students were more motivated to work together and help each other and, hence, some bad habits disappeared and good habits appeared.

The developmental progress in the traditional group was limited. With respect to students' achievement, no progress has been observed with general weakness in problem solving skills unless mathematical material was easy to be understood. The participation was mostly by high achieving students. No interaction between students had been observed. No other improvement had been observed in the other non-cognitive domain except positive attitudes and strong personality that was noted for high achieving female and male students who found the opportunity to participate in the mathematics classroom.

Chapter Nine

Conclusion, Innovations, Implications and Recommendations

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Conclusion, Innovations, Implications and Recommendations

9. Introduction

The previous chapter presented all the quantitative and qualitative findings of the study with detailed discussion of all issues that were assessed in this research. In this final chapter the researcher presents the conclusion of the study, the innovative aspects of the study, the implications of its findings for theory, practice and for future research, with several recommendations. These recommendations aim to develop the implementation of cooperative learning in the mathematics classroom and to improve the teaching and learning process in mathematics education in the light of this study.

9.1 Conclusion

The purpose of this study was to assess the effectiveness of cooperative learning strategies in promoting problem solving skills and achievement in mathematics, to analyse the views of teachers and students on the use of cooperative learning compared with traditional strategies and evaluate the general developmental progress of students exposed to cooperative learning as well as traditional classes. The other more minor aims of the study were to examine the effect of cooperative learning strategies versus the traditional ones on students' attitudes toward mathematics and its effect on students' outcomes in the non-cognitive domain. All of these aims are to examine the rationality for using cooperative leaning strategies in the mathematics classroom. Moreover, the study considered the effect of other external factors that might play a role in the teaching and learning process to introduce the findings of the study in an accurate way. Evaluating the training programme and the responses to it of teachers in the cooperative group and teaching skills that had been involved in the traditional classes are also considered within this present study.

This research constitutes an experimental study applied to a particular group (Jordanian students studying mathematics). The purpose has been to answer questions on the rationality for using cooperative learning strategies in the classroom and the affect of those strategies in enhancing problem-solving skills and achievement in mathematics. The research employed an experimental methodology and tools and research instruments developed for the purpose. The researcher recognises that a case might have been made for other tools to be adopted and applied to the research. Similarly assessments of outcomes, such as problem solving skills, do provide areas for debate. In part stimulating debate of this nature within the sometimes restrictive educational system of Jordan was the intention of the research. However, it is recognised that as a consequence the research has its limitations, both with respect to methodology and the evaluative approach adopted. Nevertheless the broad conclusions reached are amply supported by the data and should be considered in the context of the Jordanian educational system at its present stage of development.

In the light of the study, several conclusions have been drawn and explored from the discussion of the findings for the several basic issues that have been investigated within the research to examine the rationality for using cooperative learning in the mathematics classroom.

The Rationality for Using Cooperative Learning in the Mathematics Classroom

General Developmental Progress in Different Fields

- **Transferring the teaching and learning process from a teacher-centred situation into student-centred learning**

The study demonstrated that cooperative learning strategies enhanced the teaching and learning process and made a big move by transferring the teaching and learning situation from a teacher-centred situation into student-centred learning. The new situation created a wonderful environment for the learning process that enriched the cognitive, competitive and social interaction and, hence, developed several skills in the cognitive, affective and social domain.

- **Positive outcomes in the cognitive domain (enhancing mathematical achievement and promoting problem solving skills)**

The study proved the rationality for using cooperative learning especially to be applied in crowded and mixed ability classes. This is because it enhanced students' mathematical achievement and promoted their skills in problem-solving, while there was no real effect in the traditional group to enhance the mathematical achievement and to promote such skills, with one exception in the male group, where a negative effect had been found in the high-level thinking process in the standard of application and analysis especially for low achieving students. It was the view of both teachers and students that this progress had been generated through the application of cooperative learning strategies which could offer all students with different abilities the opportunities to cooperate, interact and participate in the mathematics lessons within their group. Moreover, it gave them a chance to do mathematics by themselves, speak their thoughts, give and receive explanations, introduce several procedures and solutions and, hence, profit from the mathematical knowledge available to the group as a whole. Such situations enriched the learning process and developed several practical mathematical skills. It encouraged them to challenge the problems, participate in reading the problems, draw the figures, determine the given information and understand the problems. Cooperative learning strategies enhanced the learning situation by providing students with the opportunities to speak mathematically, deal with mathematical symbols, understand mathematical concepts and rules, use algorithms in solving problems, evaluate solutions and apply these skills in solving non-routine, word problems and applications and, hence, develop their skills in problem solving. Moreover, teachers noticed that other skills were developed due to the use of cooperative learning, like reading and writing skills, computational skills, drawing figures, graphs and diagrams and dealing with games and puzzles. All previous aspects indicated that cooperative learning positively affected students' outcomes in the cognitive domain where the traditional classroom could not offer an environment to achieve such outcomes.

- **Developing other skills and enhancing positive outcomes in the non-cognitive domain**

Results in the study demonstrated that cooperative learning developed other skills in different indicators. It improved students' interaction, communication and social skills through discussing and sharing ideas, helping others and having specific roles that generated positive outcomes in the affective and social domain. It could be concluded that cooperative learning has a positive impact on enhancing students' attitudes towards mathematics because of the interest they felt through the group work and the excited atmosphere that was full of fun and activities. Moreover, developing students' behaviour and personality was a feature of other progress noticed. Students began to pay more attention to the mathematics lessons by preparing material, solving homework and contributing in out-of-class activities, such as preparing some mathematical educational aids and instructional materials. Some students in the cooperative group recommended using this teaching method in other subjects and some in the traditional group hoped to apply this teaching method in their classes. Some bad habits were decreased, such as meanness, jealously and selfishness, and good habits were increased, such as the cooperation, altruism, harmony and strong personality.

The previous indicators of students' progress demonstrated the rationality for using cooperative learning versus traditional teaching strategies because of their positive outcomes in the cognitive, affective and social domains where no real improvement had been noticed in traditional classes.

- **Gives opportunities for good classroom management**

This present study was carried out in crowded classes as is the case in most Jordanian primary schools. Results of the study found that cooperative learning could solve many problems and reduce several difficulties that teachers faced which enabled them to apply good classroom management with confidence. This teaching method allowed all students with different abilities a chance to interact and participate. It encouraged them to cooperate with their peers and, sometimes, to undertaken specific roles. On the other hand, this situation also allowed teachers a chance to follow all students, help them, assess their solutions and give them feedback with a comfortable feeling which is the opposite to those teachers in traditional classes who felt disappointed and exhausted, especially at the end of the lesson. Although some teachers pointed out that this teaching method might face some problems in arranging the classes for the need of group work, this problem was solved by the passing of time. Actually, these advantages supported and demonstrated the rationality for applying this teaching method, which presented more solutions to different problems than the traditional method that could not solve most of these problems.

- **Other different conclusions**

- The effects of students' ability

Other different conclusions could be derived from this study. Classes involved in the experiment were mixed ability classes where students were high, middle, and low achieving students. Findings of the study illustrated that outcomes of the study were largely related to students' abilities. Results indicated no real effect of applying different teaching methods on high achieving students; they can expect, anyway, to gain benefits from the mathematics lessons. It seems within this study that high achieving students prefer the competitive atmosphere rather than the cooperative one. In the view of teachers, the main factor that played a major part in the high level of achievement for those students relates to their social class and the effect of home and relatives. It could be concluded that high achieving students prefer the competitive atmosphere while other middle and low achieving students prefer the cooperative one.

The level of students' ability was not only a factor at the level of developmental progress on their mathematical achievement and problem solving skills, but it was also a factor that affected students' attitudes towards teaching methods and may also affect some students' personality. It was found that high achieving students did not feel interested and satisfied due to the application of cooperative learning which caused some frustration in spite of their positive attitudes towards mathematics as a subject. This was because the situation in cooperative learning decreased the level of the competition between high achieving students where the competitive atmosphere was between groups, not between individual students. This was a reason for some students missing the first place in the class. On the other hand, spending time helping others who may take the leading position from high achieving students caused some frustration with a low level of acceptance of mainstreamed academically handicapped students. However, the study demonstrated that cooperative learning strategies increased the feeling of interest and motivated middle and low achieving students to take part in mathematics lessons which created a positive attitude for those students toward the mathematics lessons and towards mathematics, as well. Moreover, this level of students achieved positive features and habits in their behaviour and personality. It could be concluded that the benefits differ between students according to their level of abilities.

- The effect of gender differences

Findings of the study assessed gender differences. Actually, students in Jordanian schools are separated according to gender. However, students involved in the experiment in the female and male schools were similar in their ages and grades. The same contents of material was covered, similar procedures were conducted in the two schools and the overall conditions were similar, too. This indicates that it is appropriate to make some comparison according to gender differences, although the attitudes of the students in the cooperative group were more positive than those in the traditional one in the female and male groups. Another indication has been explored which may introduce a new idea to be addressed in future research and that is the relation between achievement and attitudes. In this present study, despite female students achieving mathematically more than male students, the attitudes of the male students towards mathematics was more positive than the female group which indicates that there was no relationship between mathematical achievement and attitudes. Also, it was noticed that the female students worked with a high level of cooperation in their classes and were more enthusiastic to apply this teaching method than those in the male group. These findings referred to either gender differences, or teachers' characteristics and the relationship between students and their teachers, where a strong relationship with their teachers had been found in the male traditional group, with general satisfaction with their ability to teach mathematics in the two experimental groups.

- The effect of the type of mathematical material

The duration of the experiment for this study was extended to two scholastic semesters, which allowed opportunities to cover several mathematical branches. Findings of the study highlighted that the type of mathematical subject played a role for positive or negative effect due to the application of cooperative strategies in the mathematics classroom. Teachers observed that this teaching method positively enhanced students' mathematical knowledge and developed several mathematical skills which promote students' ability in solving problems. Despite the positive general outcomes of applying the method in the mathematics classroom, teachers pointed out that it did not affect the learning situation with subjects concentrating on mathematical proofs and the ability to use mathematical skills in proofing. Sometimes it was difficult to build a successful cooperative activity because the lesson needed the teacher's frequent intervention which disturbed the cooperative activity. It was observed that, within the duration of the experiment, this teaching method was less effective in the circle unit. Nevertheless, this instructional approach was more positive in its outcomes in other mathematical subjects: algebra, inequalities, analytical geometry, factorising and probability. The benefits they gained in such subjects were in different aspects, especially in lessons which concentrated on drawing graphs and figures, and in dealing with tables, puzzles and games. In addition, the developmental progress for different mathematical skills enabled the students to sense the benefits of mathematics and encourage them to solve non-routine problems, word problems and applications in different mathematical materials. One new, important conclusion of this present study which emphasises the significant of the research the researcher explored is that the type of mathematical subject could play a role in producing a positive or negative effect due to the application of cooperative strategies in the mathematical classroom.

- **Training programmes for effective implementation**

Evaluating the training programme indicated that teachers were very satisfied with its benefits for implementing the cooperative learning strategies effectively. Moreover, they added that, without such a training programme, it would be difficult for them to understand the real feature of this new method and how to apply it in the mathematics classroom. In the view of teachers, the training programme was comprehensive in theory and practice. The contents of the syllabus which was prepared by the researcher for use in the training programme and the discussion involved within the programme highlighted basic theoretical issues needed for implementation. Moreover, the experimental implementation (employed at the beginning of the experiment and before starting the real implementation) and introducing sample of activities and worksheets (adapted for the use of cooperative learning) helped teachers with good implementation for cooperative learning strategies in the mathematics classroom. However, they believed the training programme should be longer.

All teachers pointed to the effect of the teaching method on the learning process if it is applied in a correct way. The researcher was satisfied with the level of implementation that was developed within the duration of the experiment. Although the implementation was of a high level depending on the facilities and recourses available in the present status, it was observed that the female group was more operative and motivated in applying this new teaching method. This study demonstrated that, without a solid framework that teachers should be provided with, it would be difficult to have an effective implementation.

Since the cooperative learning strategies focused primary on the **reward** or **goal structure** under which students operate, and since the strategies that had been applied within the experiment focused on achieving other components like **individual accountability** and **team competition,** it could be concluded that this teaching approach had a positive effect of basic motivation theory where students were very **motivated and oriented towards the peer group**. They were interested in **interaction** with their peers that intensified the learning process through the exciting competitive atmosphere that was noticed throughout the experiment. On the other hand, students' incentive to master the material individually, **their contribution by giving them special subtasks** and the **group reward** that depends on the average of team scores, all contributed to an effective implementation resulting in a positive outcome. Actually, it might be difficult to get such a result without satisfying most of these basic components. In the view of teachers it was a sudden change for students to apply the new teaching method at the beginning of the experiment because they had no previous experience of how to practice cooperative group work in an effective way. The researcher recognised that the first period of the experiment was tantamount to a training course for students to apply cooperative learning. So, it is worthwhile using this teaching approach from earlier stages to encourage and help students in how to practice such skills effectively.

- **Developing teaching skills**

Teachers in the traditional group were well qualified and able to teach mathematics in a good way. Moreover, their students, were satisfied with their discussion and explanation of the mathematical subjects and a good relationship was built between them, especially in the male group. The differences between teachers in the two experimental groups were basically related to the type of teaching method involved. Cooperative learning strategies transferred the situation from a teacher's role into a student's one which gave them a chance to manage the teaching and learning process well. Moreover, it enhanced the teaching skills to concentrate on teaching strategies that engaged students in brainstorming through problem solving and encouraged students to undertake more exploration and learning by discovery through the developmental lessons. Actually, the situation in the traditional classes was different where the major role was for teachers. The crowded classes and the pressure of time forced teachers to concentrate on lecturing and exposition strategies in introducing the lessons and after that the discussion moved to asking questions and enriched the discussion by allowing a limited number of students to participate by using the board. It could be concluded that applying new teaching methods after involving teachers in a training programme was a kind of professional development for these teachers to develop their teaching skills and, instead of teachers in the traditional classes presenting the information didactically, new developmental teaching strategies engaged students in brainstorming through problem solving and encouraged the exploration and discovery techniques that enrich the reasoning thinking and develop skills at a high level of thinking.

Actually, much evidence demonstrated that it was rational to apply cooperative learning strategies in the mathematics classroom which could solve many problems that the teacher usually faced and developed several skills for both students and teachers in different domains which the traditional teaching methods could not solve or develop. So, depending on the theory and findings of this study, and others, it is worthwhile applying this teaching approach because of its different advantages, especially in promoting students' mathematical problem solving skills where students have the opportunities to practice these skills.

The researcher recognises that it is difficult to deal with people. Teachers are human beings with different characteristics and abilities. Teachers who have been trained to use cooperative learning may be strongly motivated and more enthused by the new strategies. However, teachers differ from one to another in their beliefs about the value of applying this teaching method, in their personality, their perspectives and their ability to manage the teaching and learning situation. Therefore, the level of implementation may differ from one teacher to another. On the other hand, students, also, are human beings who differ in their abilities, their personalities, their behaviour, their attitudes and their beliefs. Some students may learn more and others may learn less. The differences in students' achievement may be related to the novelty of the new method that is not familiar to them and in applying it within a specific period of time. This fact does not validate what the researcher has found. However, it may refer to such enthusiasm because of applying the new teaching method or it may refer to the high level of the involvement of students in their cooperative learning. It could be concluded that no one method is the best, either the cooperative method or others. It is worthwhile using different, new and developmental teaching styles that suit the type of the material, the quality of students and the classroom situation. However, it is the teacher's responsibility to make continuous changes in teaching strategies to reduce the routine that causes boredom for students and teachers alike. In all cases, it is concluded that teachers should use coopertive learning because of its different benefits whenever the type of the material and the learning situation are suitable to reap the benefits.

The researcher recognises that this study was conducted within the real practice in Jordan. No attempt has been made in the study to select special circumstances or conditions in Jordan but, rather, typical educational environments have been used with all the normal strengths and weaknesses.

9.2 Innovations of the Study

This present experimental cooperative learning research is thought to be unique and different in several ways compared to other subjects in the field of teaching and learning mathematics.

- **Innovative aspects of the model of implementation**

The model of cooperative learning strategies which teachers were trained to use in the implementation was a mixture of several cooperative strategies. They are generated from different cooperative learning methods, especially student teams-achievement divisions (STAD), learning together, group investigation and, sometimes, a form of teams-games-tournaments (TGT) (see chapters four and five). This combination was considered to achieve most of the basic components in cooperative learning and to facilitate the application for such research in a way that does not contradict the educational system in Jordan which forced teachers to cover specific mathematical subjects within a specific period of time; also, because students' outcomes should be considered as an individual academic achievement. For implementing these strategies effectively, the researcher prepared a good organised syllabus used within the teacher training programme. This programme is to provide teachers with all the information needed about these strategies including: the teachers' role, the teachers' decisions, when and how to apply cooperative learning strategies and how to adapt mathematics lessons for the use of cooperative strategies with specific worksheets and activities derived from the Jordanian mathematics curriculum.

- **Innovative aspects of the students' outcomes**

This present study was thought to be unique in searching for, especially, the effect of cooperative learning strategies on students' problems solving skills. Therefore, consideration was given to preparing the pre- and the post-achievement tests with different standards of objectives and behaviour in the cognitive domain: knowledge and computations, comprehension, application and analysis. Moreover, dividing the results of the students' outcomes into two separate levels (low and high levels of thinking) gave the researcher the opportunity to determine exactly how cooperative learning might affect students' problem solving skills. In addition to that, interviews, observations and diaries provided the researcher with evidence about students' developmental progress in skills which were difficult to measure by tests. Incidentally, most research concentrates on general achievement while there is a lack of research, on problem solving skills.

One basic aim of this present study was to examine the rationality for using cooperative learning strategies in the mathematics classroom. The theoretical models concentrate on motivational and cognitive theory (Slavin, 1990; Terwel et al, 1994; Abrami et al. 1995; and Millis and Cottel, Jr, 1998). Moreover, cooperative learning is a social instructional approach. So, it was expected that cooperative learning has different advantages in the cognitive and non-cognitive domain. For these reasons, the researcher searched for other outcomes on students' attitudes towards mathematics and outcomes in the non-cognitive domain to assess its general advantages and, hence, to examine the rationality for using this teaching method.

In brief, this study was possibly unique in searching for the effects of cooperative learning strategies on students' mathematical problem solving skills as a special case in general mathematical achievement, moreover, it was possibly unique in searching for students' attitudes towards mathematics and other expected outcomes in the non-cognitive domain.

- **Innovative aspects of the mathematical subjects involved**

The mathematical material covered during the experiment was varied to include several branches of mathematics: algebra, probability, geometry, inequalities. This allowed the researcher, through the qualitative data analysis, to investigate different outcomes that were found to be related to the type of the mathematical subjects. This study was thought to be unique in covering several mathematical materials.

- **Innovative aspects for different and variety quantitative and qualitative collected data instruments**

Several quantitative and qualitative approaches were employed (pre-test, post-test, questionnaire, interviews, observations and diaries) to collect data.

- **Innovative aspects to be applied in Jordan**

This type of empirical research study is thought to be unique, in its application in the Jordanian Upper Primary Basic Schools.

9.3 Implications of the Study for Theory and Practice with Recommendations

Results of the study have different implications for theory and practice. These implications may provide several benefits by employing the results of the study in the mathematical educational system to improve the teaching and learning process in mathematics and to develop the Jordanian Educational System in the future.

- Positive impact on the learning achievement of mathematics in different fields

Several research studies found that cooperative learning can have a positive impact on learning achievement in different learning fields: the cognitive, the social and the affective domain (Sharan 1980, Slavin, 1980, 1983b, 1985a, 1987b, 1990a, 1991; Kerry and Sands, 1982; Kagan, 1986; Johnson and Johnson, 1987, Johnson and Johnson, 1989; Reid, Forrestal and Cook, 1989; Good et al, 1989/1990; Davidson, 1990a; Shanahan, Topping and Bamford, 1994; Stevens and Slavin, 1995; Peklaj, 1996 and others). Findings of this present study supported these results. The benefits of applying cooperative learning strategies in the mathematics classroom suggest that this teaching approach should be applied in teaching mathematics. Also, findings of the study support other researchers who demonstrated the need to apply cooperative learning in the mathematics classroom (Davidson, 1990a; Johnson and Johnson, 1990; Terwel, 1990; Runesson, 1997; and Jones and Wakefield, 1998). Teachers should be encouraged to use cooperative strategies in their classes to gain benefits and to achieve most of their gaols for the purpose of improving the teaching and learning process in the mathematics classroom and to enhance students' general mathematical achievement.

- Positive effect in promoting problem solving skills

In a deep look at the advantages of cooperative learning, it was found more effective in promoting deep learning since the ability to do mathematics is the ability to solve problems is considered the highest form of learning. Many researchers highlighted the need to master these kinds of skills and promote students' ability in critical thinking through problem solving. Many researchers mentioned the effectiveness of cooperative learning in promoting problem-solving skills and the suitability to use it as an instructional method in problem solving lessons to help bridge the gap between computational skills and problem solving (Lesh, 1981; Gilbert-Macmillan and Leitz, 1986; Cobb et al, 1988; Rosenhaum et al, 1989; Artzt and Newmann, 1990, 1997; Bershon, 1992; Heller, Keith and Anderson, 1992; and Davenport and Howe, 1999). Some researchers highlighted the point that cooperative problem solving is a learning situation rich with social interaction that is necessary to improve the inner speech and the cognitive development. Results of this present study supported previous research findings where positive effect was found due to the application of cooperative learning strategies in improving students' problem solving skills and their ability to solve non-routine, word problems and applications. Quantitative data analysis found a positive effect due to the application of this teaching method in promoting students' ability in the standard of application and analysis. Moreover, the qualitative data analyses explored how cooperative learning enhanced the learning situation and promoted different kinds of skills. So, both quantitative and qualitative findings suggested that this teaching method should be applied in the mathematics classroom, especially in problem solving lessons.

- The positive or negative effect related to the type of the mathematical subject in applying cooperative learning

An important result of this special research, where several mathematical subject were involved, explored the type of mathematical subject and the feature of the mathematics lesson played an obvious role emphasising positive or negative effect. It was found that (through the qualitative data analysis) while this teaching method was more effective in most mathematical subjects (probability, inequalities, factorising, and analytical geometry, and its problem solving, especially in the mathematics lessons that dealt with tables, games, puzzles and drawing graphs, diagrams and figures). It was less effective in the circle unit and it was negatively effective in the lessons which dealt especially with the mathematical proofs. This result gives a new indication that several teaching methods should be used within mathematical subjects and the role for teacher is to decide and choose the most suitable teaching method according to the mathematical subject and the feature of the mathematics lessons.

It is recommended that future research studies should concentrate on the effect of cooperative learning strategies on different mathematical subjects and branches to develop the implementation of the teaching method in the mathematics classroom. Moreover, it is recommended that search is made for different developmental and modern teaching methods to serve the teaching and learning mathematical process in all its different branches. The need for more research, related to the positive effect, was found due to the application of cooperative learning strategies in several mathematical fields. Moreover, there is a need for more progressive methods other than the traditional instructional method which did not solve the problems raised when the cooperative learning did not, either.

- Attitudes towards mathematics

One of the aims of the study was to assess students' attitudes towards mathematics and if the attitudes related to the effect of the teaching method involved. Findings of the study in the quantitative part illustrated that, in general, cooperative learning positively affected students' attitudes towards mathematics compared with the affect of the traditional methods, which supports previous findings (Drzewiecki and Westberg, 1997; Yusof and Tall, 1999). Despite this result, quantitative data also found that, although female students achieved more than male students did, the male group had more positive attitudes towards mathematics than the female one. This result indicates that, in this study, there was no relationship between students' attitudes and students' achievement in the two experimental groups as a whole, which does not support other studies that suppose that there is a relationship between these two outcomes. More research is recommended in that field. Furthermore, qualitative data analysis explored that the positive attitudes for the male group might relate to the strong relationship that was built with their teachers, the gender differences, or other reasons. More research is recommended to assess the relationship between these factors and their effect on the mathematical achievement.

- Other outcomes in the non-cognitive domain

To examine the rationality for using cooperative learning strategies in the mathematics classroom, and because of the previous research findings about the advantages of this teaching method in the non-cognitive domain, this present study took part in a search for other expected outcomes in the non-cognitive domain. Findings of the study supported previous researchers' findings of the positive effect for applying the cooperative learning on:

- inter-group relations (Webb, 1985; Schmuck, 1985; Johnson and Johnson, 1985; Good et al, 1989/1990; Davidson, 1990a, Slavin, 1990a; and Hertz-lazarowitz and Miller, 1992; Webb and Farivar, 1994, Townsend and Hick, 1997)
- peer academic support (Slavin, 1990a; Quah and Jones, 1997; and Jones and Wakefield, 1998)
- time on-task (Johnson and Johnson, 1985; Slavin, 1990a)
- liking of school, class and classmates (Kagan, 1985, Johnson and Johnson, 1985; and Slavin, 1990a).

On the other hand, findings of the study did not support other studies where no positive effect was found in this present study on:

- acceptance of academically handicapped students (Johnson and Johnson, 1985; Slavin, 1990a; Stevens and Slavin, 1995) especially for high achieving students who prefer the competitive atmosphere rather than the cooperative one
- self-esteem (Slavin, 1985a, 1990a)
- internal locus of control (Slavin, 1990a; Jones and Wakefield, 1998).

The negative results in the last two expected outcomes can be explained by the researcher's own special philosophy that changing something in human personality needs much time but there was limited time in such research. Also, many factors may affect building up this personality that is established from birth. More specific and basic research is recommended to search for the outcomes in the non-cognitive domain. It is also recommended that this teaching method should be applied from earlier stages.

- **The effect of other external factors**

This present research took note of the effect of other external factors that might influence the teaching and learning process. The consideration of these factors gave different indicators during the analytical stage. The implications of these findings may gain benefits by using these results.

- **Students' ability**

One of these factors was students' ability. This study was undertaken in mixed ability classes, which contained high, middle and low achieving students. Findings explored within the qualitative data analysis illustrated that the effect of the teaching method is strongly related to students' ability in the cooperative group. It was found that there was no real effect for applying this teaching method for high achieving students while a positive effect was found for middle and low achieving students. Moreover, students' perspectives and satisfaction in applying the cooperative method differred according to their ability. While most low and average achieving students were more enthusiastic, satisfied and in agreement with applying this teaching method, high achieving students were less in agreement where it caused some kind of frustration for some of them. In addition, teachers commented that the major role for the high achievement of those students basically related to their social class and parents' culture. More specific research is recommended to assess the effects of these factors. For the purpose of improving the application of the cooperative method in such mixed ability classes, it is recommended that teachers should use strategies to adapt individual needs, especially for high achieving students. So, making some kinds of competitions between high achieving students in different groups could be a solution for this problem. It is recommended, also, to involve heterogeneous and homogenous ability classes in future research.

- **Gender differences**

Gender differences were considered through all the analytical stages of this study because there are basic assumptions about the way in which boys and girls typically differ from each other (Cooper and Dunne, 2000). Findings of the study supported these assumptions. In some special cases, findings of the study did not support the results of Drzewiecki and Westberg (1997) who suggested that cooperative grouping may not be as advantageous for females as traditional instruction for promoting positive general attitudes towards mathematics. On the other hand, findings of this study supported Owens and Straton (1980) that there were clear and significant differences between the preferences for mode of learning, cooperative, competitive and individualistic, of males and females over the range of grades from fourth to eleventh year. More research in that field is recommended.

- **Curriculum**

Several researchers (Cooper and Dunne, 2000; Terwel and Eeden, 1992; and Terwel et al, 1994) pointed to the relationship between curriculum implementation and students' learning. In this present study, the curriculum was fixed by the Ministry of Education in Jordan. The same topics were taught, finished and evaluated within the scholastic academic year for the research implementation in the two experimental groups. Actually, the analytical stage supported this relationship between the type of mathematical subject and the degree of effectiveness of applying cooperative learning strategies where, most times, it was very effective and, sometimes it was not. Teachers involved in the experiment, especially in the cooperative group, mentioned that the Jordanian mathematics curriculum was not well prepared to serve the application of cooperative learning or even any other teaching method. Because of that, and because of the hard efforts of the teacher under pressure of a heavy load of lessons per week, teachers used the traditional approach in spite of their dissatisfaction with it. Teachers in the cooperative group added that preparing and modifying mathematics lessons for the use of group work was sometimes difficult and took much effort. Without the assistance that the researcher provided them at the beginning of the experiment, especially in the training programme by introducing several forms of Jordanian mathematics lessons and how to adapt them for using cooperative group work, and introducing several types of activities and worksheets. Even without the training programme, it would have been difficult for teachers to modify some of the mathematical contents of the present curriculum for the use of group work. The textbook, even the teacher's guide, gives very poor examples of how to use different teaching approaches in teaching mathematics. The curriculum is very poor for introducing different activities and problems that may be used for cooperative work. On the other hand, teachers commented that the amount of material in the curriculum is very large compared with the time available to cover the mathematical subjects, the types of the questions are mostly knowledge and not analytical ones. Even the discussion for the lessons in not clear for students to understand. The need to develop the teaching and learning process in the Jordanian Educational System requires a great deal of interest and concern.

It is worthwhile to recommend here that the Curriculum and Textbook Authority in the Ministry of Education in Jordan should develop the contents of the textbooks and teacher's guides in a way which would help teachers to use different teaching methods, especially if it is cooperative learning that needs a special curriculum developed by a specialist in that field. It is recommended that a teachers' guide is provided with different teaching strategies, especially cooperative group work, so that teachers could choose the most suitable one as an instructional method to encourage and help them to apply different teaching approaches. Moreover, teacher's guides should provide teachers with accurate information and descriptions about different mathematics teaching methods, including complete examples of lessons adapted to be taught by more than one method of instruction. Actually, during the interviews with teachers, the researcher noticed that teachers did not have good backgrounds of different teaching strategies they could use and, really, they could not give educational terms to the strategies they usually used in their classes. It is recommended, also, in this situation, that teachers should be provided with different forms and examples of activities, worksheets games and puzzles that could suit the group work in different mathematics lessons to encourage them to choose this method of instruction. It is worthwhile, also, to pay attention to the contents of the mathematics textbooks. It is recommended that the contents be divided into sub-units that could be taught and implemented by using group work. Moreover, introducing different forms of activities, games and puzzles that could be modified for the use of group learning will also encourage students to apply cooperative learning.

The experience that the researcher had in a British school as a mathematics teacher gave her a good chance to look at different mathematics curriculum and mathematical educational resources. Really, there is a big gap between the available resources for both teachers and students. It is worthwhile recommending that the Curriculum and Textbook Authority should provide teachers with different mathematical resources. This would enrich them with different sorts of mathematical knowledge, activities, games, instructional materials and aids, and different modern mathematical educational materials, to give teachers more chances to apply different modern and progressive teaching strategies, especially group learning, in an effective and comfortable way.

- **Improving the learning process through problem solving**

Although findings of the study illustrated that cooperative learning promoted students' mathematical problem solving skills, much evidence indicated that students are still weak in mastering these skills to say that they have became problem solvers. All participators in the Jordanian Educational System, including teachers, supervisors, curriculum and textbook authorities and all decision makers, are encouraged to concentrate on the importance of problem solving from the basic stages. This is to improve the learning process and to build students' personality in such a way that would result in them being decision makers and problem solvers.

- **Developing pre- and in-service training programmes**

Using cooperative learning strategies in the mathematics classroom requires a different approach to planning and teaching than the traditional methods of instruction. Therefore, the teacher should be well trained to incorporate this teaching method successfully in the classes. Teachers should understand it well and they should be given guidance regarding its application (Robertson, Graves, and Tuck, 1990; Burns, 1990; and Terwel, 1990). Evidence through the fieldwork of this study and interviews with teachers supported these assumptions. Teachers commented that, without the training programme they were involved in with the researcher, it would be difficult to understand exactly what this teaching method meant, what its basic components are and how to implement it in their classes.

In order to improve the teaching and learning process in Jordanian schools as a main goal of the educational system, teachers training programmes in Jordan should benefit from the findings of this study in both stages, pre- and in-service. Results of this present study found that traditional expository teaching methods were inferior in promoting students' mathematical achievement, especially at a high-level of thinking, and problem solving skills compared with the cooperative one. Therefore, teachers should be encouraged to use other, different, teaching methods, especially cooperative learning. The need for more training programmes is recommended which provide teachers with different teaching approaches, especially cooperative learning, in order to provide them with a basic framework to understand the features of these methods and how to implement them effectively in the mathematics classroom. Moreover, these training programmes should be supported by class visits from supervisors and trainers to give teachers necessary feedback and recommendations for the purpose of improving the model of implementation.

Findings of this present study, through the analytical stage to evaluate teachers' teaching skills in the two experimental groups, identified that cooperative learning enhanced the teaching and learning process and added new teaching skills to those who were trained in how to use this new teaching method. It was observed that, while teachers in traditional classes concentrated on the exposition strategies and discussion by asking questions (where the basic role is for teacher), teachers in cooperative classes used different teaching strategies that concentrated on discovery and exploration strategies (where the basic role is for students). This transformation related to the application of cooperative learning, which helped teachers to use new and developed teaching strategies in such crowded classes where it was difficult to use such strategies in the traditional method. Moreover, the training programme was a form of professional development for teachers to use this teaching method as a progressive one. It is recommended that teachers be trained and encouraged always to use strategies that support the students' rather than the teachers' role.

9.4 Further Recommendations

Several recommendations were mentioned in previous sections, some of them on the grounds of practice and others for future research. In the light of the study, further consideration could be given to develop mathematics classroom research, especially in Jordan, but, generally, in other countries all over the world.

This present study was limited by the time for implementation. Students were from the same grade and approximately the same age (eighth grade, approximately 14-15 years old). Teachers involved in the experiment were chosen in such a way to have the same qualifications and approximately the same number of years of experience. Therefore, results of this study cannot be generalised with such limitations. It is recommended that more research be conducted for different stages and ages through different primary stages. Teachers with different qualifications and experiences should be involved in searching for the relationship between teachers' experiences, qualifications and the standard of implementation. It is also recommended that studies and research should be of longer duration. It is recommended that, if large projects that involve different grades and teachers with different experiences were funded by responsible authorities for 3-4 years, fruitful developmental projects might be conducted.

It is worthwhile to recommend that future research should concentrate on gender differences, students' ability, attitudes towards mathematics, mathematics teachers and mathematics lessons, the effect of the social class and the relation between these factors and students' mathematical achievement.

It is recommended that all research should use different quantitative and qualitative triangulation analysis because it is difficult to explain some results through quantitative data alone.

Finally, it is recommended that the Jordanian Educational System should be developed, especially in mathematics, by encouraging all the participators in the educational field to use different and modern teaching strategies which support the students' role; moreover, to raise the mathematical teaching and learning process to enhance it from the standard of theory to the standard of practice.

All educationalists should cooperate and work together to make the learning of mathematics more practical and sensible everywhere and all the time by raising it through different life situations and applications. This could be achieved by concentrating on the importance of mathematical problem solving and the concern to improve students' skills in solving problems.

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List of

APPENDICES

Appendix one

Pre-test (mathematical achievement and problem solving assessment) with its piloting form

a) Pre-mathematical test

Pre- mathematical test for grade eight

Student Name:..................
Grade:.................
Teaching method:............
Sex:............

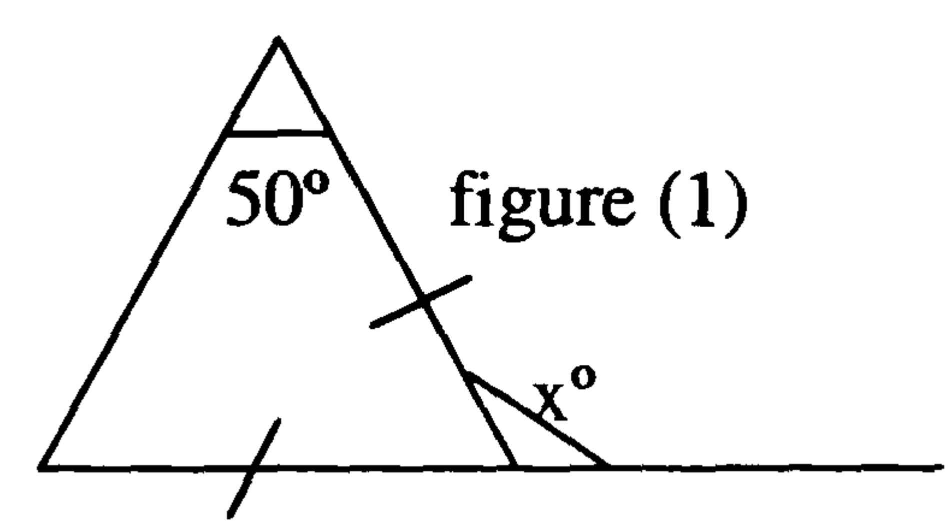
<u>The First Question</u> **(10 Marks)**

Shadow the symbol for the correct answer:

1. The decimal fraction $0.\overline{17}$ is equal to

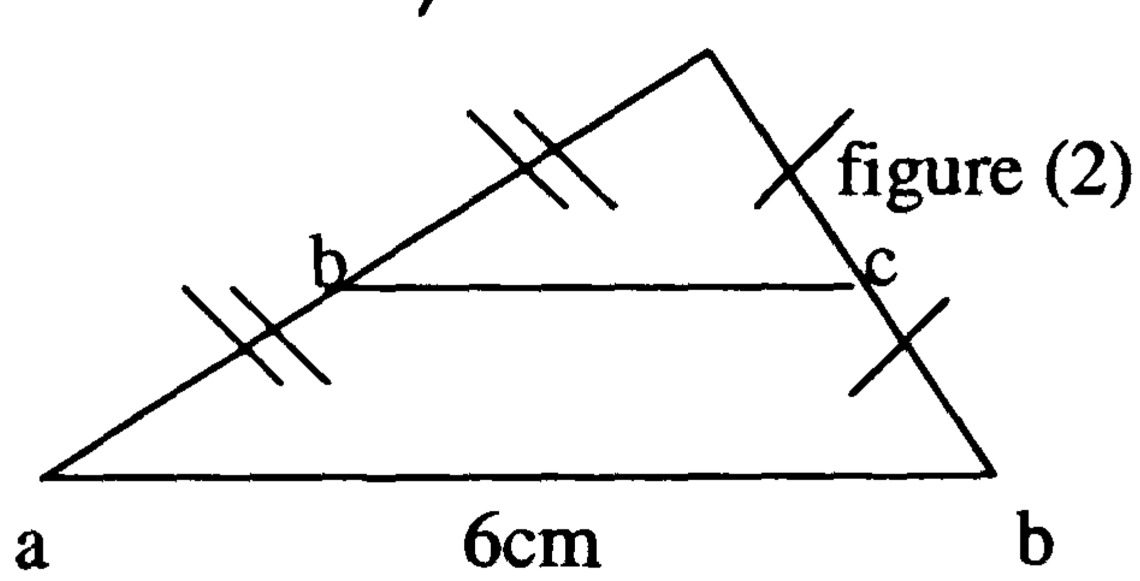
a) $\frac{17}{100}$ b) $\frac{17}{99}$ c) $\frac{7}{10}$ d) $\frac{7}{9}$

2. $\angle x$ in figure (1) is equal to



a) 50° b) 80° c) 90° d) 100°

3. bc in figure (2) is equal to



a) 3 cm. b) 6 cm. c) 9 cm. d) 12 cm.

4. The algebraic expression = (x^2-y^2)

a) $(x-y)(x+y)$ b) $(x^2-y^2)(x^2+y^2)$ c) $(x-y)^2$ d) $(x+y)^2$

5. The algebraic expression $(y^2-3)(2y+1) =$

a) $2y^3 - 3$ b) $y^2 - 6y + 1$ c) $y^2 + 2y - 2$ d) $2y^3 + y^2 - 6y - 3$

6. The algebraic expression $(x+3)^2 =$

a) $x^2 + 6x + 9$ b) $x^2 + 9$ c) $(x-3)(x+3)$ d) $(x-3)$

7. One of the following is not a solid figure

a) the sphere b) the cube d) the cylinder d) the triangle

8. The volume of a sphere its radius is 6 cm. is equal to (hint: $v = 4/3\ \pi\ r^3$)

a) $144\pi\ cm^3$ b) $144\pi\ cm^2$ d) $288\pi\ cm^2$ d) $288\pi\ cm^3$

9. A rectangle paper, its length is 10 cm. and its wide is 5 cm. had been rotated as a cylinder shape its height is 5 cm. . What is the perimeter of the base of the cylinder?

a) 5 cm. b) 10 cm. d) 15 cm.) 2 cm.

10. Which of the following real numbers is an irrational number ?

a) $\sqrt{9}$ b) 0.9 c) 0.9191……. d) 0.919119111……

The second question

Find the value of the following:

1) $\sqrt{10}$ correct to 2 decimal places. ***(3 marks)***

………
………
………
………………………………………………

2) $\sqrt{50}\ \sqrt{2}$ ***(3 marks)***

………
………
………
………………………………………………

3) $\dfrac{(7 \times 9)^{-3} \times 3^{9}}{7^{-2}}$ ***(3 marks)***

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………
………
………………………………………………

The third question

1. 12 persons insured on their life in an insurance company for £ 10000 for each person. By monthly payment its value is £ 20 for each one of them for 10 years. One of them died during this period after 18 months. **What is the gain or loss value for the insurance company?** ***(3 marks)***

....

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....

....

....

2. June bought goods from a commercial company for £ 1400 . She wrote a bill of debt which must be paid after 6 months, if the value of the current bill of debt after the discount is equal to £ 1344. **Find the following:**

a) **The value of the discount.** *(2 marks)*

....

....

....

b) **The percentage of the discount.** *(3 marks)*

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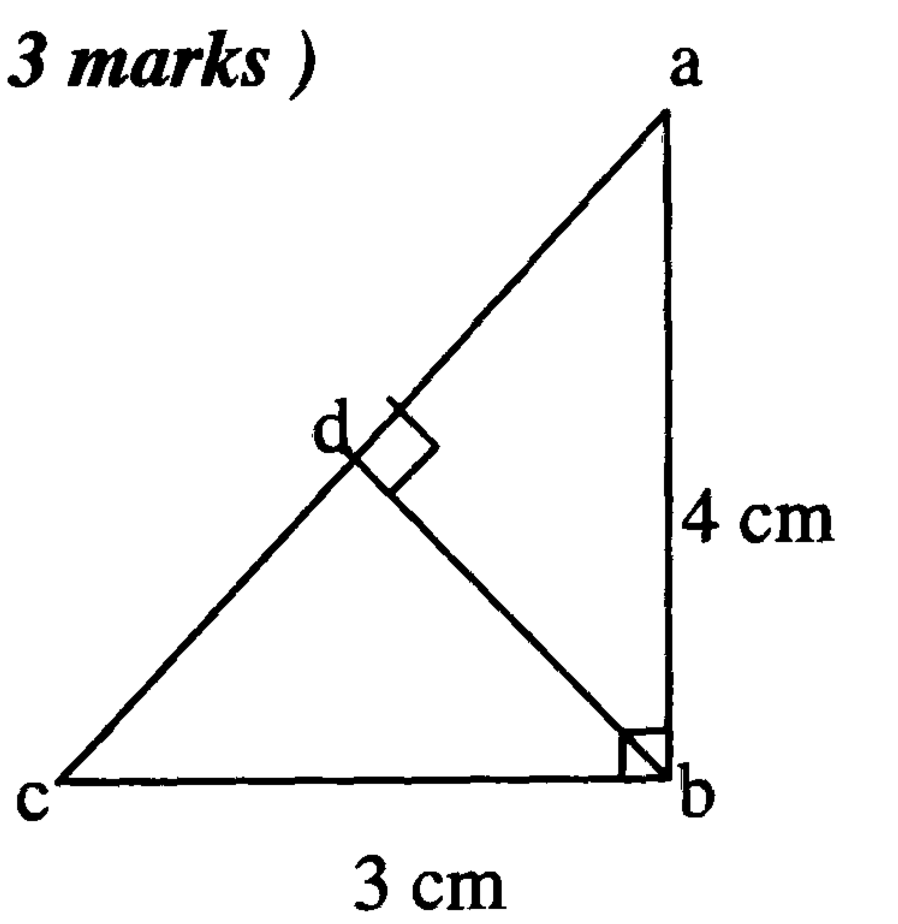
The fourth question

1. In figure (3) *(3 marks)*

Find bd and explain your steps.



figure(3)

....

....

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....

....

2. Two buildings, their heights are 20 m. and 15 m. and the distance between them is 12 m. . We want to extend a wire between the two highest points in them. **What is the shortest length of the wire?** *(3 marks)*

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....

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....

3. **Prove that** : The projected perpendicular from the head of an isosceles triangle on the base bisects the base and bisects the angle of the head. ***(3 marks)***

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<u>The fifth question</u>

1. **Analyse the following algebraic expression.** **(2 marks)**

$6x^2 - 14x - 12$

....
....
....
....

2. A square farm, the length of its side is 54 m. . There is a road its width is 1 m. around it.

a) find the area of that road by using the difference between two squares.
(3 marks)

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....

b) Check your answer by using alternative method. **(3 marks)**

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....

3. A water tank's shape is a cone with height 4 m. and capacity 4800 litre.

a) **find the area of the base of the tank.** **(3 marks)**

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....
....

b) **find the relation between the slant height of the cone and its radius.**
(3 marks)

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....
....
....

GOOD LUCK

b) **Pre-test Piloting Form.**

Dear Teacher, Dr., or Prof.;

The researcher is working on a study under the title **"An Assessment of the Effectiveness of Cooperative Learning Strategies in Promoting Problem-Solving Skills and Achievement in Mathematics** " to get the Ph.D degree in mathematics education.

The objectives of this study are to examine the rationality for using cooperative learning in mathematics and determine how this strategy may be applied most effectively and, also, to assess the effectiveness of cooperative learning strategies on promoting problem-solving skills and achievement in mathematics. This will be measured by experimental methodology. The sample will be two groups of students (male and female) from the eighth grade in the upper basic stages. All of the students will take a pre-test in the contents of the mathematics text book in the first semester to measure the achievement of the students in mathematics and the skills of problem-solving.

The first group will be taught by the traditional method while the researcher will train a number of teachers in how to use cooperative learning strategies in the mathematics classroom so that they can teach the second group by using cooperative leaning strategies. At the end of the experiment the researcher will give a post-test to the all students in the two groups to measure the achievement and the skills of problem-solving in mathematics. The data in the pre-test and the post-test will be analysed to assess the effectiveness of cooperative learning strategies in promoting problem-solving skills and achievement in mathematics.

This test is considered one of the research instruments which will be used as a pre-test to measure the achievement for the eighth basic stage students in the contents of the mathematics text book in the first semester and before applying the experiment. This exam will measure the objectives and behaviour categories in the cognitive field according to Bloom's categories.

1. knowledge and computations

Knowledge here includes the following:
a) knowing particulars, concepts, terminology, and facts and remember the symbols which denoted these concepts and terminology
b) knowing the methods and means of dealing with particulars and facts, such as assessing the basic hypothesis
c) knowing the principals, laws, roles, theories and the characteristics of shapes.

Computations include working out the mathematical calculating operations and using the methods and algorithms to find out the solutions such as finding the addition or multiplication of two matrixes or solving equations,... etc.

2. Comprehension

Understanding and comprehension here means that the whole understanding and knowledge of the concepts and laws and the ability of the students to transfer the ideas from one form to another and finding the relations which link the ideas and the concepts with each other. Also, it means the knowledge of the students for the mathematical instruction and his or her ability to use a specific algorithm in thinking and give a specific interpretation for a mathematical problem or mathematical situation.

3. Application

Application means the ability of the students to use the mathematical information which has been known and understood in a new situation. During the application the student will remember the information which has been studied, choose the suitable information and facts and work for the applied task.
In application the student may solve routine mathematical problems, with special algorithms to be solved, make a comparison and analyse data.

4. Analysis

The student in analysis will make high standard of mind thinking, such as: to solve non-routine mathematical problems, discover the relations, prove and evaluate his proof, discover the laws and ensure the truth of it.

The ratio for the previous categories in the exam will be as follows:

knowledge and computations (20%)
comprehension (30%)
application (30%)
analysis (20%).

Because of your experience in this field, please pilot the questions of the test on the piloting form by putting (√) if it is correct, if not put your remark on the piloting form according to:

a) the relevance of each question to the previous categories
b) the language correction
c) any other changes by deletion or adding

Thank you very much for your efforts and for your help.
Be sure that your answers will be used for the needs of the scientific research only.

Please answer the following questions
The name: ....
The academic qualification: ....
Number of years of experience: ....

Please complete the following table where
Q : denotes question's number.
( ) : denotes branch's number.
KC : denotes knowledge and calculation.
UC : denotes understanding and comprehension.
AP : denotes application.
AN : denotes analysis.

The question	Category classification		Language correction	Other remarks
Q1(1)	KC			
Q1(2)	UC			
Q1(3)	UC			
Q1(4)	UC			
Q1(5)	KC			
Q1(6)	KC			
Q1(7)	KC			
Q1(8)	KC	-		
Q1(9)	UC			
Q1(10)	AN			
Q2(1)	KC			
Q2(2)	UC			
Q2(3)	UC			
Q3(1)	AP			
Q3(2-a)	KC			
Q3(2-b)	AP			
Q4(1)	UC			
Q4(2)	AP			
Q4(3)	AN			
Q5(1)	UC			
Q5(2-a)	AP			
Q5(2-b)	AN			
Q5(3-a)	AP			

Q5(3-b)	AN			

Please write down your general opinion about the exam with respect to the nature of the questions, the distribution of the remarks, the standard of the questions and any other remarks you think that will be helpful.

....
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....

MANY THANKS FOR YOUR EFFORTS AND HELP

THE RESEARCHER
AREEJ BARHAM
THE UNIVERSITY OF HUDDERSFIELD
ENGLAND

c) Pre-test Marking Scheme

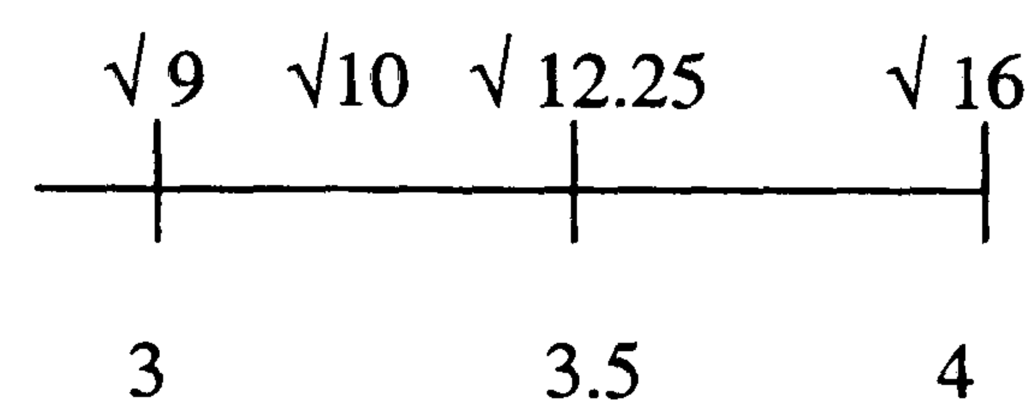
The First Question

Question Number	The Answer	The Mark
1	b	1mark
2	d	1 mark
3	a	1 mark
4	b	1 mark
5	d	1 mark
6	a	1 mark
7	d	1 mark
8	d	1 mark
9	b	1 mark
10	d	1 mark

The Second question

1) find out the value of $\sqrt{10}$ correct to 2 decimal places.

The Answer:



$9 < 10 < 16$

$\Rightarrow \sqrt{9} < \sqrt{10} < \sqrt{16}$

$\Rightarrow 3 < \sqrt{10} < 4$

$\Rightarrow \sqrt{10} \cong (3+4)/2 = 3.5$ (correct to 1 decimal point) (1 mark)

Now $(3.5)^2 = 12.25$

But $9 < 10 < 12.25$

$\Rightarrow \sqrt{9} < \sqrt{10} < \sqrt{12.25}$ (1 mark)

$\Rightarrow 3 < \sqrt{10} < 3.5$

$\Rightarrow \sqrt{10} \cong (3+3.5)/2 = 3.25$

$\Rightarrow \sqrt{10} \cong 3.25$ (correct to 2 decimal points) (1 mark)

Total (3 marks)

2) find out $\sqrt{50}\sqrt{2}$

The Answer:

$\sqrt{50}\sqrt{2} = \sqrt{50 \times 2}$ (2 marks)

$= \sqrt{100} = 10$ (1 mark)

Total (3 marks)

3) Find out $$\frac{(7 \times 9)^{-3} \times 3^{9}}{7^{-2}}$$

The Answer:

$\dfrac{(7 \times 9)^{-3} \times 3^{9}}{7^{-2}} = \dfrac{7^{-3} \times 9^{-3} \times 3^{9}}{7^{-2}}$	(1 mark)
$= 7^{-3} \times 7^{2} \times (3^{2})^{-3} \times 3^{9}$	
$= \dfrac{3^{3}}{7}$	(2 marks)
$= \dfrac{27}{7}$	(1 mark)
Total	(3 marks)

The Third Question

1) 12 persons insured on their life in an insurance company for £ 10000 for each person. By monthly payment its value is £ 20 for each one of them for 10 years. One of them died during this period after 18 months. **What is the gain or loss value for the insurance company?**

The Answer:

The amount which is paid by the death person = 18 x 20 = 360 £	
The total amount which is paid by the other persons = 11 x 20 x 12 x 10 = 26400 £	(1 mark)
Hence, the total amount that the company had received = 360 + 26400 = 26760 £	(1 mark)
But, the company paid 10000 £ for the death person.	
And since 26760 > 10000	
∴The company gained 26760 – 10000 = 15760 £	(1 mark)
Total	(3 marks)

2) June bought goods from a commercial company for £ 1400 . She wrote a bill of debt which must be paid after 6 months, if the value of the current bill of debt after the discount is equal to £ 1344. **Find the following:**

a) **The value of the discount.**

The Answer:

The value of the discount = the denominated value – the present value

= 1400 – 1344 = 56 £ (2 mark)

b) **The percentage of the discount.**

The Answer:

Let the percentage of the discount = P (1 mark)

Since,

the value of the discount = the denominated value x the percentage of discount x period in years

$\Rightarrow$ 56 = 1400 x P x (6 / 12)

$\Rightarrow$ 56 = 700 P (1 mark)

$\Rightarrow$ P = 56 / 700

$\Rightarrow$ P = 8 / 100

$\Rightarrow$The percentage of discount = 8 % (1 mark)

Total (3 marks)

The Fourth Question

1. In figure (3)

Find bd and explain your steps.

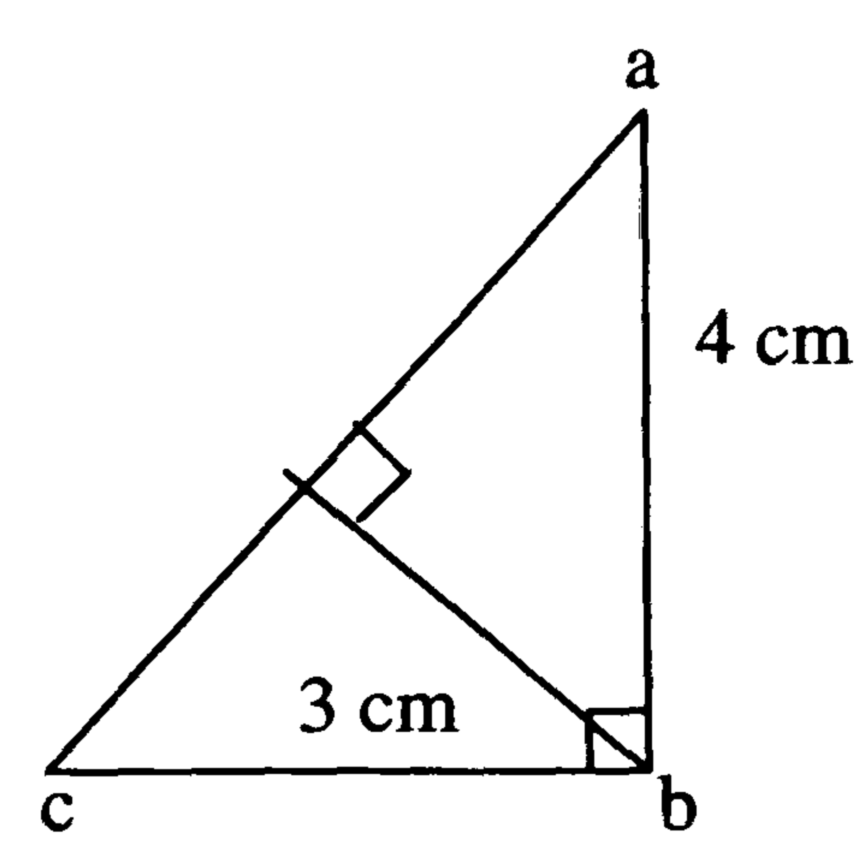


figure (3)

The Answer:

In $\Delta\Delta$ abc and dbc

$\angle$abc = $\angle$ cdb (right angles)

$\angle$c = $\angle$c (combined angle)

$\Rightarrow \Delta\Delta$ abc and dbc are similar (1 mark)

$\Rightarrow \frac{ab}{ac} = \frac{bd}{cb}$ (1 mark)

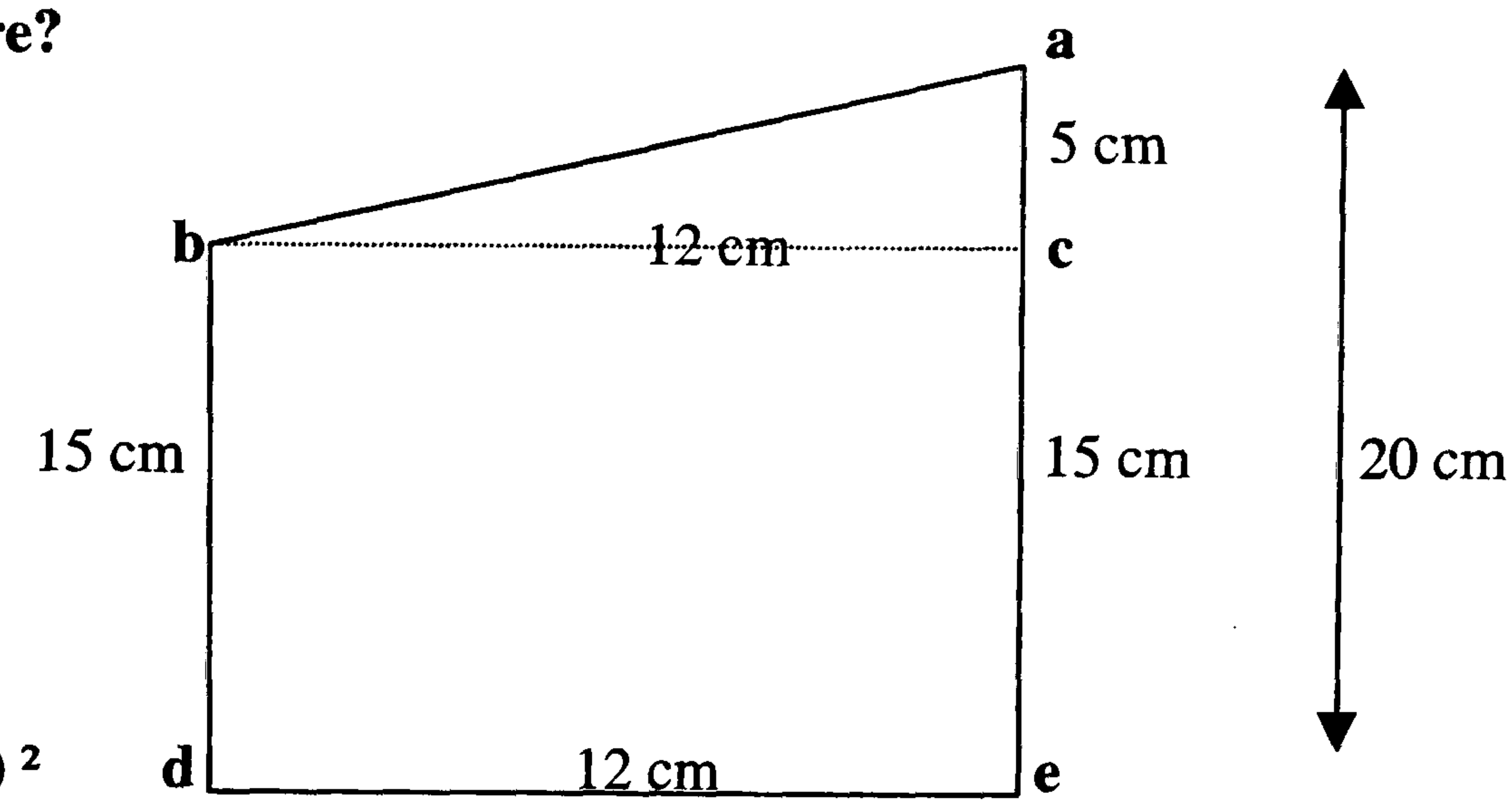
But, ab = $\sqrt{4^2 + 3^2} = \sqrt{25} = 5$ (1 mark)

$\Rightarrow$ 4 / 5 = bd / 3 $\Rightarrow$ bd = (3 x 4) / 5 = 12 / 5

Total (3 mark)

3) Two buildings, their heights are 20 m. and 15 m. and the distance between them is 12 m. . We want to extend a wire between the two highest points in them. **What is the shortest length of the wire?**

The Answer:



Let ab = the shortest distance

(2 marks)

In Δ abc we have

$(ab)^2 = (bc)^2 + (ac)^2 = (12)^2 + (5)^2$

$144 + 25 = 169$

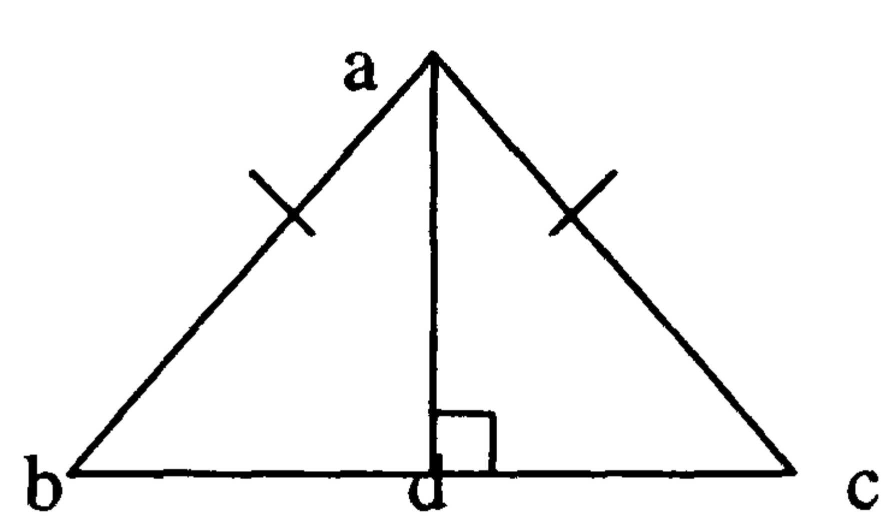
$\Rightarrow$ ab 13 (1 mark)

$\Rightarrow$ The shortest length of the wire = 13 m

Total (3 marks)

4) **Prove that** : The projected perpendicular from the head of an isosceles triangle on the base bisects the base and bisects the angle of the head.

The Answer:



Let abc a triangle where:

ab = ac

ad $\perp$ bc

want to prove that:

bd = cd .... (1)

$\angle$ bda = $\angle$ cad ....(2) (1 mark)

In $\Delta\,\Delta$ abd and acd

ac = ab ....(given)

$\angle$ adc = $\angle$ adb = 90 ° ....(given)

ab = ad ....(combined)

$\Rightarrow \Delta\,\Delta$ abd and acd are identical (1 mark)

Hence, bd = dc and $\angle$ bda = $\angle$ cad (1 mark)

Total (3 marks)

The Fifth Question

1) Analyse the following algebraic expression.

$6x^2 - 14x - 12$

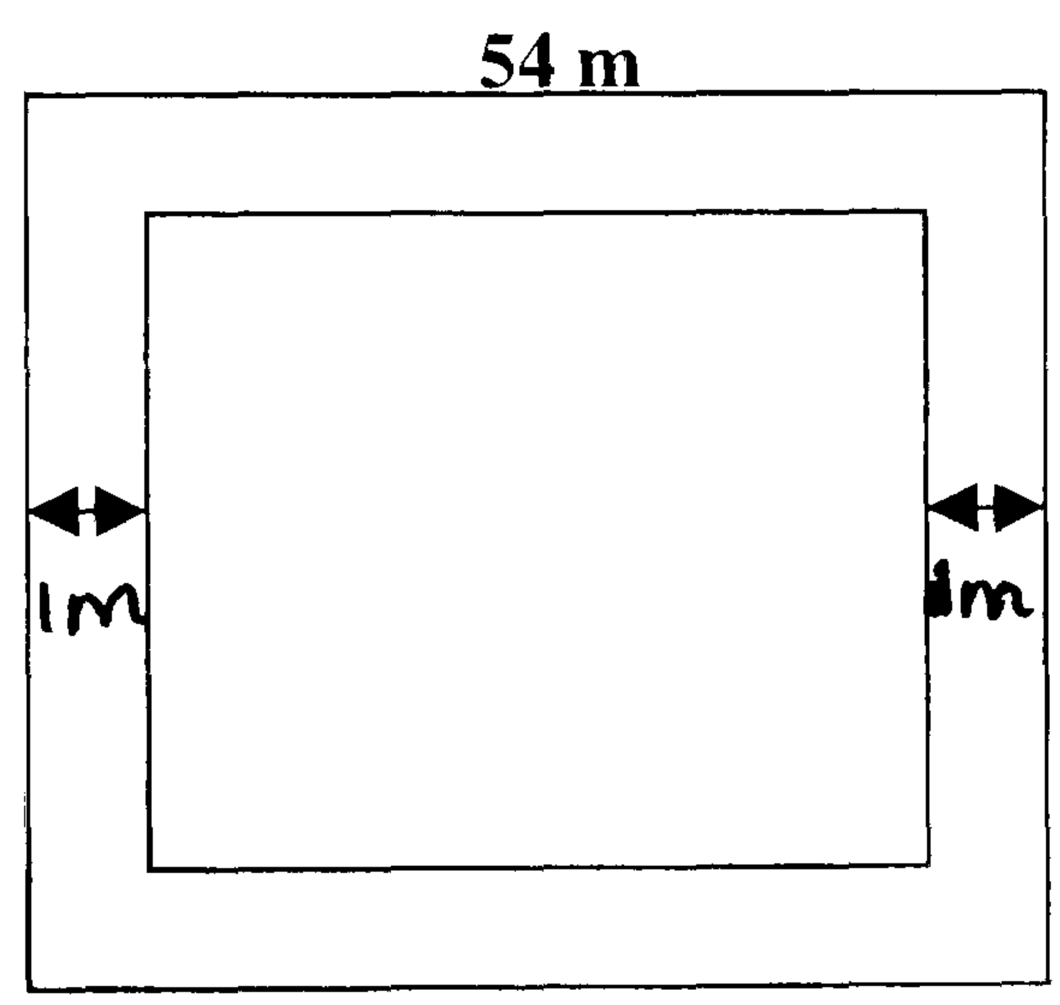
The Answer:

$6x^2 - 14x - 12 = 2(3x^2 - 7x - 6)$	(1 mark)
$= 2(3x + 2)(x - 3)$	(1 mark)
Total	(2 marks)

2) A square farm, the length of its side is 54 m. . There is a road its width is 1 m. around it.

a) find the area of that road by using the difference between two squares.

The Answer:



Area = $(54)^2 - (52)^2$	(1 mark)
Since	
$x^2 - y^2 = (x - y)(x + y)$	
$\Rightarrow$ area = $(54 - 52)(54 + 52)$	(1 mark)
$= 2 \times 106 = 212\ m^2$	(1 mark)
Total	(3 marks)

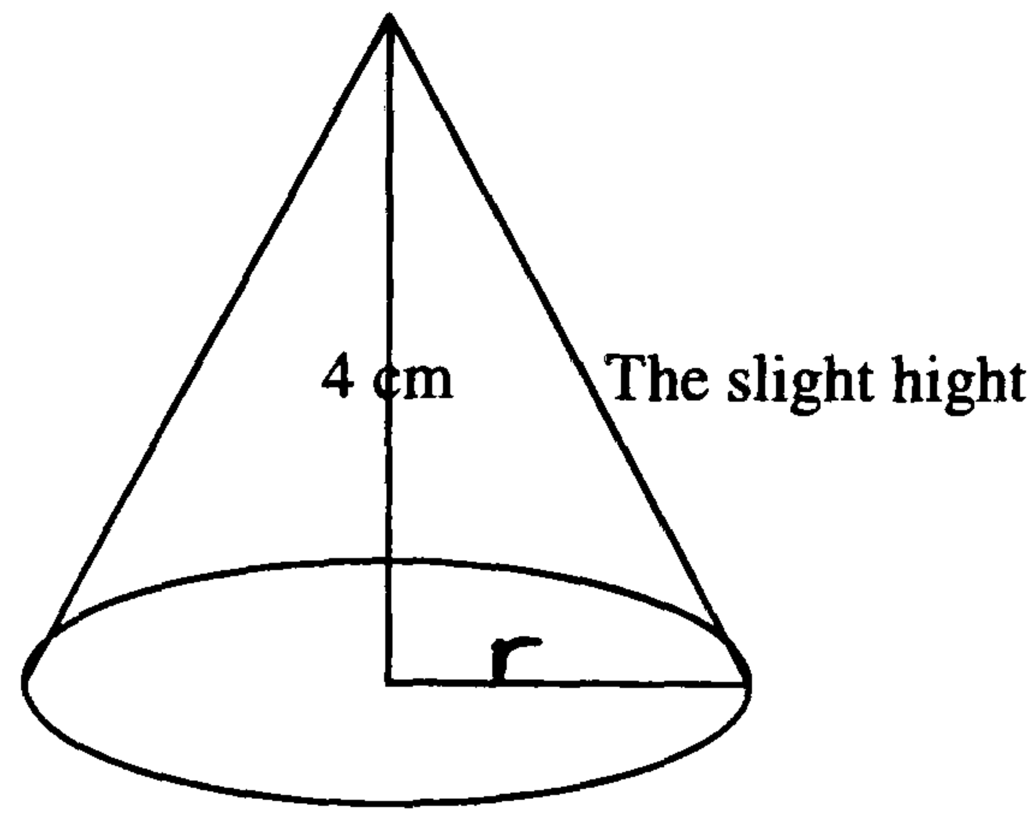
b) Check your answer by using alternative method.

Area = $54^2 - 52^2$	(2 marks)
$= 2916 - 2704 = 212\ m^2$	(1 mark)
Total	(3 marks)

3) A water tank's shape is a cone with height 4 m. and capacity 4800 litre.

a) find the area of the base of the tank.

The Answer:



(1 mark)

Volume = area of base x height (1 mark)

4800 = area of base x 4

$\Rightarrow$ area = 4800 / 4 = 1200 m^2 (1 mark)

Total (3 marks)

b) find the relation between the slant height of the cone and its radius.

The Answer:

From the previous figure

$(\text{Slight height})^2 = r^2 + 4^2$ (2 marks)

$\Rightarrow$ Slight height = $\sqrt{16 + r^2}$ (1 marks)

Total (3 marks)

Appendix Two

Post–test (mathematical achievement and problem solving skills assessment) with its Piloting Form

a) Post Mathematical Achievement Test.

Post mathematical test for grade nine.

Student Name:..................
Grade:.................
Teaching method:...........
Sex:............

The First Question: Shadow the symbol for the correct answer. (24 marks)

1) The distance between the two points a(2,3) and b(2,8) is equal to

a) 25 units b) 5 units c) 36 units d) 6 units

2) The slope of the straight line that passes through the two points x(1,3) and y(2,-5) is equal to

a) $\frac{1}{8}$ b) $\frac{-1}{8}$ c) 8 d) -8

3) In figure (1) cd may form

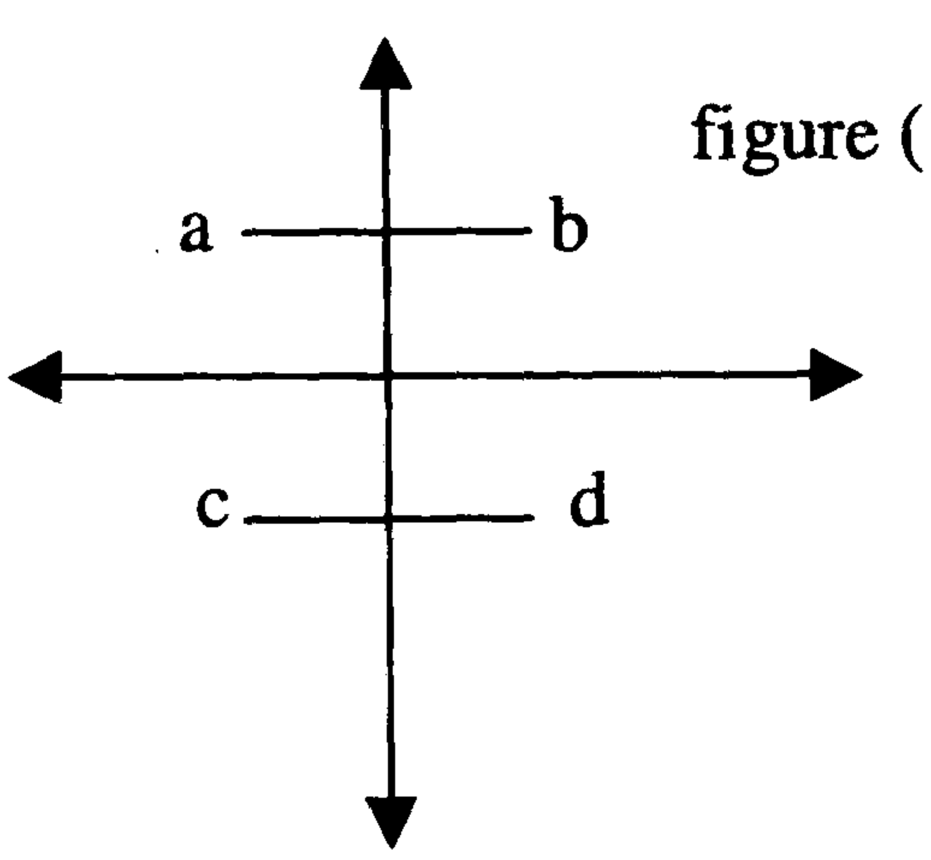


figure (1)

a) Only a reflection of a b .
b) Only a symmetric of a b.
c) Only a translation of a b.
d) Reflection, symmetry and translation of a b

4) The algebraic expression $8x^3-1$ =

a) $(2x+1)(4x^2+2x+1)$ b) $(2x-1)(4x^2+2x+1)$
c) $(2x+1)(4x^2-2x+1)$ c) $(2x-1)(4x^2-2x+1)$

5) The greatest common factor for the two algebraic expressions $x^2 + x$ and $x^2 - 1$ is equal to

a) x b) x -1 c) x +1 d) $x(x^2 - 1)$

6) In the previous question the least common factor is equal to

a) x b) x -1 c) x +1 d) $x(x^2 - 1)$

7) The algebraic expression $\frac{x-1}{x^2-1}$ is equal to

a) x −1 b) x + 1 c) $\frac{1}{x-1}$ d) $\frac{1}{x+1}$

8) A circle with centre c and radius 3 cm. If a b is a diameter in the circle then a b is equal to

a) 3 cm b) 6 cm c) 9 cm d) 12 cm

9) In figure (2) if
O is the centre of the circle,
a and b two points lye on the circle.
The angle a is equal to 40°.
The angle O is equal to

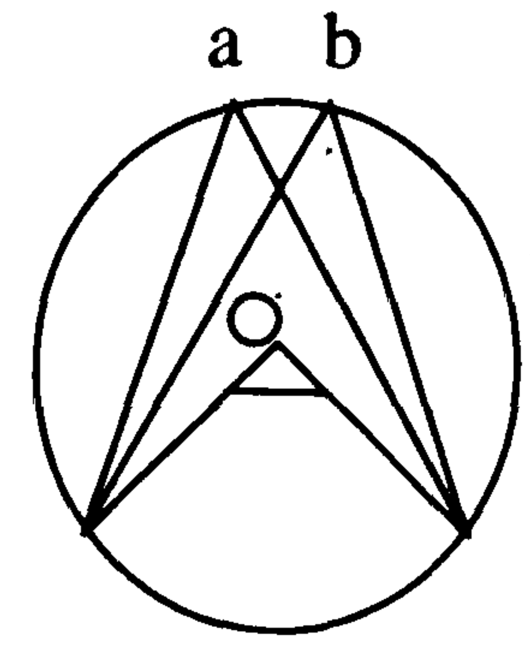


figure (2)

a) 20° b) 40° c) 80° d) 90°

10) in the previous figure the angle b is equal to

a) 20° b) 40° c) 80° d) 90°

11) which of the following statements is correct

a) $\sqrt{5} \leq \sqrt{3}$ b) $\sqrt{8} < \sqrt{8}$ c) $\sqrt{5} \geq \sqrt{3}$ d) $\sqrt{8} > \sqrt{8}$

12) If $-2x > 8$ then

a) $x > 4$ b) $x < 4$ c) $x > -4$ d) $x < -4$

The Second Question **(7 Marks)**

a) If a(0,0), b(3,0), c(3,2), and d(0,2) are vertexes of a rectangle. A translation is made for the rectangle by 5 units above.

1) What are the co-ordinates of the vertexes after the translation? (1Mark)

....

....

2) What is the area of the new rectangle? (2 Marks)

....

....

3) What is the relation between the area of the rectangle before and after the translation? (1 Mark)

....

b) A straight line passes through the point (-2,6) and its slope is 4. Find the coordinate of its intersection point with the Y axis? (3 Marks)

....
....

The Third Question **(7 Marks)**

a) The multiplication of two algebraic expressions is $8x^3 - 18x^2 - 5x + 21$. If one of them is $2x - 3$, find the other expression. (4 Marks)

....
....

b) One number consists of two different digits, another number consists of the same digits of the first number but with different order of the digits. Prove that the division of the positive difference between the square of the two numbers over the positive difference between the square of the two digits is equal to 99. 3(Marks)

....
....
....

The fourth Question **(6 Marks)**

If a b is a chord in a circle, its length is 24 cm and it is far from the centre of the circle by 5 cm, c d is another chord in the circle and it is far from the circle by 12 cm.

a) find the radius of the circle. (4 Marks)

....
....

b) find the length of c d. (2 Marks)

....
....

The Fifth Question: **(6 Marks)**

One trader advertised his needs to a goods distributor, and he will pay for him either 100 & monthly payment with commission 2 % of the total sales, or 120 & monthly payment with commission 3 % of the sales that is acceded than 3000 &.

a) Find the total sales that makes the first offer better than the second one if the total sales is always more than 3000&. (4 Marks)

....
....
....

b) Make sure that your solution is correct. (2 Marks)

....
....

GOOD LUCK

b) **Piloting Form for the Post Test.**

Dear Teacher, Dr., or Prof.;

The researcher is working on a study under the title **"An Assessment of the Effectiveness of Cooperative Learning Strategies in Promoting Problem-Solving Skills and Achievement in Mathematics "** to get the Ph.D degree in mathematics education.

The objectives of this study are to examine the rationality for using cooperative learning in mathematics and determine how this strategy may be applied most effectively and, also, to assess the effectiveness of cooperative learning strategies on promoting problem-solving skills and achievement in mathematics. This will be measured by experimental methodology. The sample will be two groups of students (male and female) from the eighth grade in the upper basic stages. All of the students will take a pre-test in the contents of the mathematical text book in the first semester to measure the achievement of the students in mathematics and the skills of problem-solving.

The first group will be taught by the traditional method while the researcher will train a number of teachers in how to use tcooperative learning strategies in the mathematics classroom so that they can teach the second group by using cooperative leaning strategies. At the end of the experiment the researcher will give a post-test to the all students in the two groups to measure the achievement and the skills of problem-solving in mathematics. The data in the pre-test and the post-test will be analysed to assess the effectiveness of cooperative learning strategies in promoting problem-solving skills and achievement in mathematics.

This test is considered one of the research instruments which will be used as a post-test to measure the achievement for the eighth basic stage students in the contents of the mathematics text book in the first semester of the ninth grade in the upper basic stage and after applying the experiment for two semesters. This exam will measure the objectives and behaviour categories in the cognitive field according to Bloom's classification such as:

1. knowledge and computations.

Knowledge here includes the following:

a) knowing particulars, concepts, terminology, and facts and remember the symbols which denoted these concepts and terminology
b) knowing the methods and means of dealing with particulars and facts, such as assessing the basic hypothesis
c) knowing the principals, laws, roles, theories and the characteristics of shapes.

Computations including working out the mathematical calculating operations and using the methods and algorithms to find out the solutions such as finding the addition or multiplication of two matrixes or solving equations,... etc.

2. Comprehension

Understanding and comprehension here means that the whole understanding and knowledge of the concepts and laws and the ability of the students to transfer the ideas from one form to another and finding the relations which link the ideas and the concepts with each other. Also, it means the knowledge of the students for the mathematical instruction and his or her ability to use a specific algorithm in thinking and give a specific interpretation for a mathematical problem or mathematical situation.

3. Application

Applications means the ability of the students to use the mathematical information which has been known and understood in a new situation. During the applications the student will remember the information which have been studied, choose the suitable information and facts and work for the applied task.
In applications the student may solve routine mathematical problems, with special algorithms to be solved, make a comparison and analyse data.

4. Analysis

The student in analysis will make high standard of mind thinking, such as: to solve non-routine mathematical problems, discover the relations, prove and evaluate his proof, discover the laws and ensure the truth of it.

The ratio for the previous categories in the exam will be as follows:
knowledge and calculations (20%)
understanding and comprehension (30%)
application (30%)
analysis (20%).

Because of your experience in this field, please pilot the questions of the test on the piloting form by putting (√) if it is correct, if not put your remark on the piloting form according to:

a) the relevance of each question to the previous categories
b) the language correction
c) any other changes by deletion or adding.

Thank you very much for your efforts and for your help.
Be sure that your answers will be used for the needs of the scientific research only.

Please answer the following questions:
The name: ....
The academic qualification: ....
Number of years of experience: ....

Please complete the following table where
Q : denotes question's number.
( ) : denotes branch's number.
KC : denotes knowledge and calculation.
UC : denotes understanding and comprehension.
AP : denotes application.
AN : denotes analysis.

The question	Category classification		Language correction	Other remarks
Q1(1)	KC			
Q1(2)	KC			
Q1(3)	UC			
Q1(4)	KC			
Q1(5)	UC			
Q1(6)	UC			
Q1(7)	UC			
Q1(8)	KC			
Q1(9)	UC			
Q1(10)	UC			
Q1(11)	KC			
Q1(12)	UC			
Q2(a-1)	UC			
Q2(a-2)	AP			
Q2(a-3)	AP			
Q2(b)	AN			
Q3(a)	AP			
Q3(b)	AN			
Q4(a)	AP			
Q4(b)	AN			
Q5(a)	AP			
Q5(b)	AN			
Q5(b)	AP			

Please write down your general opinion about the exam with respect to the nature of the questions, the distribution of the remarks, the standard of the questions, the time for the exam and any other remarks you think that it will be helpful.

....
....
....
....
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MANY THANKS FOR YOUR EFFORTS AND HELP

THE RESEARCHER
AREEJ BARHAM
THE UNIVERSITY OF HUDDERSFIELD
ENGLAND

c) Post-test Marking Scheme

The First Question

Question Number	The Answer	The Mark
1	b	1 mark
2	d	1 mark
3	d	1mark
4	b	1 mark
5	c	1 mark
6	d	1 mark
7	d	1 mark
8	b	1 mark
9	c	1 mark
10	b	1 mark
11	c	1 mark
12	d	1 mark

The Second Question:

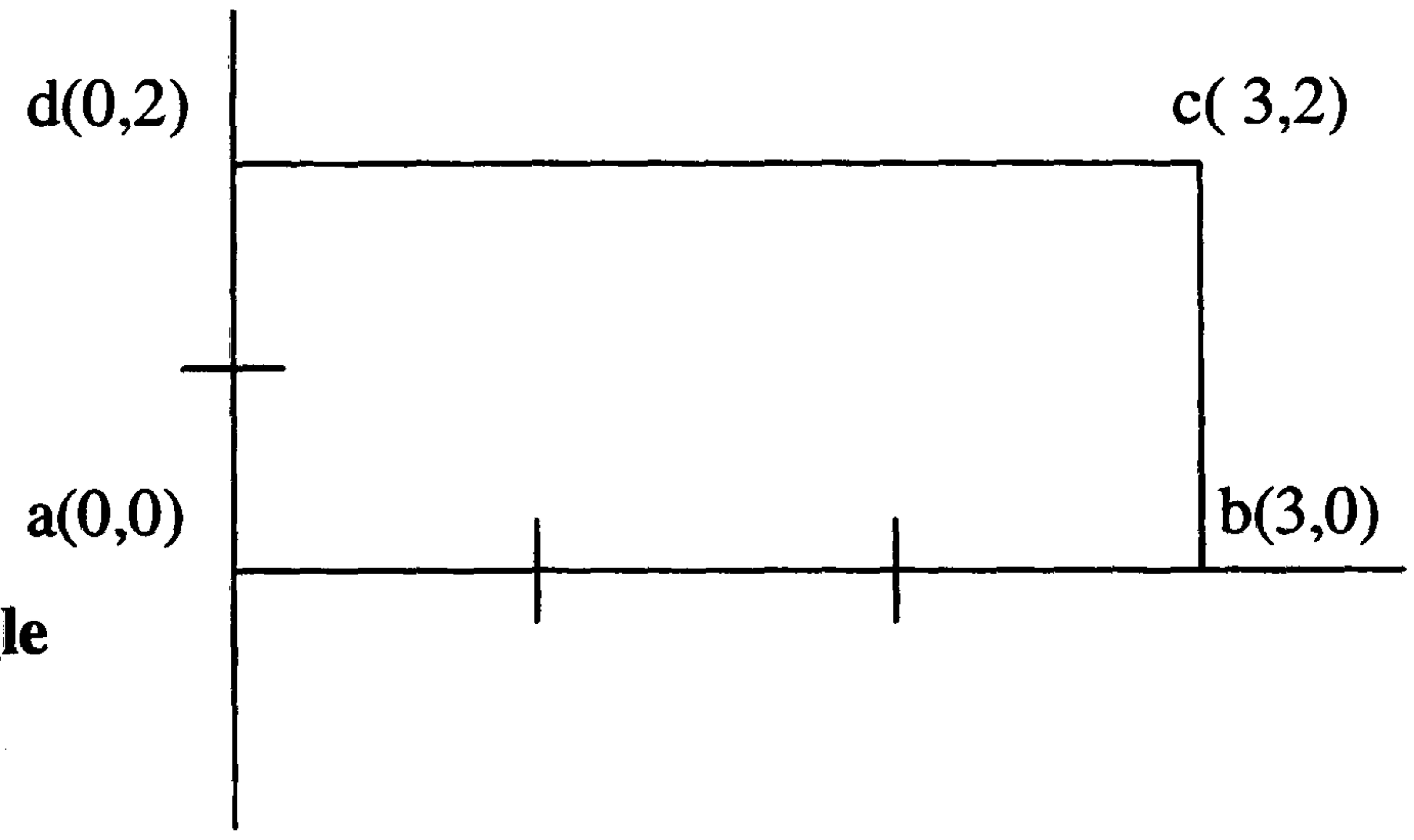
a) If a(0,0), b(3,0), c(3,2), and d(0,2) are vertexes of a rectangle. A translation is made for the rectangle by 5 units above.

1) What are the co-ordinates of the vertexes after the translation?

The Answer:

The co-ordinates are

a′(0,5), b′(3,5), c′(3,7) and d′(0,7) (1 mark)



2) What is the area of the new rectangle

Answer:

Area = length x wide

= 3 x 2 = 6 unit ^{2} (2 marks)

3) What is the relation between the area of the rectangle before and after the translation?

Answer:

The same (1 mark)

Total (4 marks)

b) A straight line passes through the point (-2,6) and its slope is 4. Find the coordinate of its intersectio point with the Y axis?

Answer:

The intersection point with the Y axis $\Rightarrow x = 0$

since slope = (y – yo) / (x – xo) ....(1)

but the line passes through the point (-2,6)

$\Rightarrow$ (xo , yo) = (-2 ,6) (1 mark)

and since the line intersect the Y axis

$\Rightarrow$ (0, y) satisfies the equation (1)

$\Rightarrow 4 = (y - 6) / (0 - (-2))$ (1 mark)

$\Rightarrow 4 = (y - 6) / (0 + 2)$

$\Rightarrow 2 \times 4 = y - 6$

$\Rightarrow 8 = y - 6$

$\Rightarrow y = 8 + 6 = 14$

the intersection point with the Y axis is (0, 14) (1 mark)

Total (3 marks)

The Third Question

a) The multiplication of two algebraic expressions is $8x^3 - 18x^2 - 5x + 21$. If one of them is $2x - 3$, find the other expression.

The Answer:

$(2x - 3)$ (the other expression) = $8x^3 - 18x^2 - 5x + 21$

$\Rightarrow$ the other expression = $(8x^3 - 18x^2 - 5x + 21) \div (2x - 3)$ (1 mark)

$4x^2 - 3x - 7$

$2x - 3 \;|\; 8x^3 - 18x^2 - 5x + 21$

$8x^3 - 12x^2$ (opposite the signs) (1 mark)

$-6x^2 - 5x + 21$

$-6x^2 + 9x$ (opposite the signs) (1 mark)

$-14x + 21$

$-14x + 21$ (opposite the signs) (1 mark)

0

$\Rightarrow$ the other expression is $4x^2 - 3x - 7$

Total (4 marks)

b) One number consists of two different digits, another number consists of the same digits of the first number but with different order of the digits. Prove that the division of the positive difference between the square of the two numbers over the positive difference between the square of the two digits is equal to 99.

The Answer:

Let the first number is m and the second number is n

Let the two digits that the numbers consists of them are a and b

$\Rightarrow m = a + 10\,b$ and $n = b + 10\,a$

Want to prove that

$$\frac{|m^2 - n^2|}{|a^2 - b^2|} = 99$$ (1 mark)

Now $$\frac{|m^2 - n^2|}{|a^2 - b^2|} = \left| \frac{(a + 10\,b)^2 - (b + 10a)^2}{a^2 - b^2} \right|$$

$$= \left| \frac{a^2 + 20\,ab + 100\,b^2 - (b^2 + 20\,ab + 100\,a^2)}{a^2 - b^2} \right|$$

$$= \left| \frac{a^2 + \cancel{20\,ab} + 100\,b^2 - b^2 - \cancel{20\,ab} - 100\,a^2}{a^2 - b^2} \right|$$

$$= \left| \frac{a^2 - 100\,a^2 + 100b^2 - b^2}{a^2 - b^2} \right|$$ (1 mark)

$$= \left| \frac{a^2(1-100) + b^2(100 - 1)}{a^2 - b^2} \right|$$

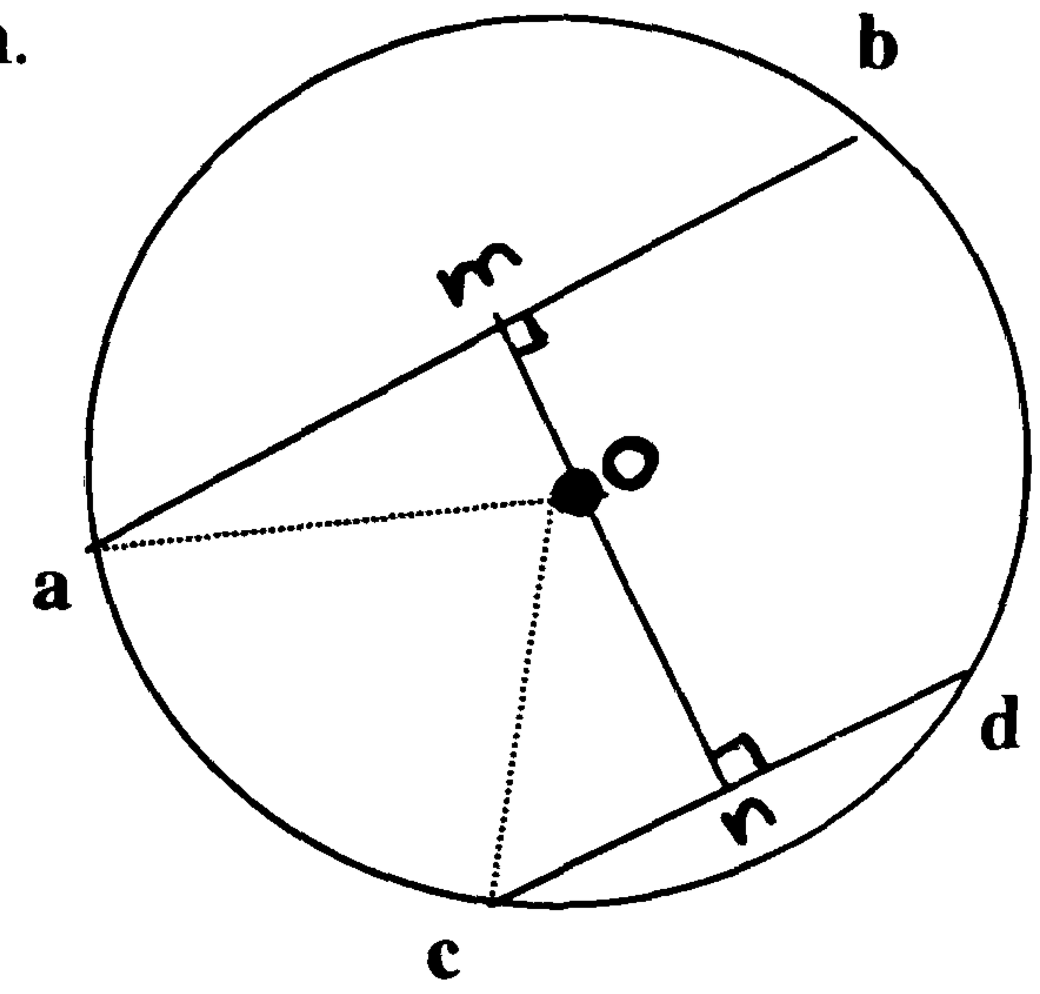
$$= \left| \frac{a^2(1-100) - b^2(1 - 100)}{a^2 - b^2} \right|$$

$$= \left| \frac{-99\,(\cancel{a^2 - b^2})}{(\cancel{a^2 - b^2})} \right| = |-99| = 99$$ (1 mark)

Total (3 marks)

The fourth Question

If a b is a chord in a circle, its length is 24 cm and it is far from the centre of the circle by 5 cm, c d is another chord in the circle and it is far from the circle by 12 cm.



a) find the radius of the circle.

The Answer:

let o the centre of the circle **such that:**

om $\perp$ ab and on $\perp$ cd (2marks)

$\Rightarrow$ ma = 12 cm (half of the chord)
and since om = 5 cm

$\Rightarrow$ oa = $\sqrt{(12)^2+(5)^2}$ = 13 cm (Pythagoras' theorem) (1 mark)

$\Rightarrow$ the radius of the circle = 13 cm (1 mark)

Total (4 marks)

b) find the length of c d.

The Answer:

Since the radius of the circle = 13 (proved in part a)

And since on = 12 cm (given)

$\Rightarrow$ cn = $\sqrt{(13)^2 - (12)^2}$ = 5 (Pythagoras' theorem) (1mark)

But cn is half of the chord cd

$\Rightarrow$ cd = 10 cm (1 mark)

Total (2 marks)

The fifth Question

One trader advertised his needs to a goods distributor, and he will pay for him either 100 & monthly payment with commission 2 % of the total sales, or 120 & monthly payment with commission 3 % of the sales that is acceded than 3000 &.

a) Find the total sales that makes the first offer better than the second one if the total sales is always more than 3000&.

The Answer:

Let x denotes the amount of the sales

$\Rightarrow$ x > 3000

$\Rightarrow 100 + (2 / 100)\, x > 120 + (3 / 100)\,(x - 3000)$		(1 mark)
$\Rightarrow (2 / 100)\, x - (3 / 100)\,(x - 3000) > 120 - 100$		
$\Rightarrow (2 / 100)\, x\ (3 / 100)\, x + 90 > 20$		
$\Rightarrow - (x / 100) > - 70$		
$\Rightarrow\ - x > - 7000$		
$\Rightarrow\ x < 7000$		(1 mark)
but $x > 3000$		
$\Rightarrow\ 7000 > x > 3000$		(1 mark)
$\Rightarrow$ the total sales that makes the first offer better than the second offer is greater than 3000 and less than 7000.		(1 mark)
	Total	(4 marks)

b) Make sure that your solution is correct.

The Answer:

To make sure that the answer is acceptable		
if $x = 3001$		
$\Rightarrow$ the total income from the first offer is equal to		
$100 + (2/100)\,(3001) = 160.02$ £		
and the total income from the second offer is equal to		
$120 + (3/100)\,(3001 - 3000) = 120.03$		
where $160 .02 > 120.03$ then, the solution is acceptable		(1mark)
also if $x = 6999$		
$\Rightarrow$ the total income from the first offer is equal to		
$100 + (2 / 100)\,(6999) = 239.98$		
and the total income from the second offer is equal to		
$120 + (3 / 100)(6999\text{-}3000) = 239{,}97$		
where $239.98 > 239.97$ then, the solution is also acceptable		(1 mark)
	Total	(2 marks)

Appendix Three

Programme Evaluation Questionnaire

<u>Programme Evaluation Questionnaire</u>

Teaching method:........................
Sex:..............

Dear Student,

The statements that are mentioned in the following pages aim to assess the effectiveness of teaching methods in mathematics in different fields: its effect on the academic achievement in mathematics and the problem solving skills, outcomes other than the achievement, attitudes of the students toward mathematics, their perspectives toward the method applied in teaching mathematics and the search for other external factors may affect the students' performance.

Each statement carries a specific idea which you may agree or disagree with and you are asked to respond to each statement in a way which describes your real opinion and your feelings and not in a way that you think you should feel. It is not an examination of your information or your ability, but it is to assess your response on the idea that the statement carries. Please, select the choice that best reflects your response towards the following statements by putting (x) in the space provided for each statement.

Key: SA (Strongly Agree)
A (Agree)
U (Uncertain)
D (Disagree)
SD (Strongly Disagree)

This is for the first four parts of the questionnaire. Please answer the last part by putting (x) in the in the space provided for each statement by selecting the choices Yes or No.

Be sure that your answers will be used for the scientific research objectives only.
Thank you very much for your help and cooperation.

The Researcher

Part One

Students' perspectives about teaching method effects on achievement and problem solving skills

NO.	The Statements	The responses				
		SA	A	U	D	SD
1.	Teaching method develops the mathematical knowledge for me.					
2.	Teaching method does not increase my understanding of the difficult concepts.					
3.	Teaching method helps my higher achievement in mathematics.					
4.	Teaching method encourages me to use the new mathematical vocabulary words properly.					
5.	Teaching method helps me to understand the mathematical rules.					
6.	Teaching method increases my ability to use the concepts and rules in solving mathematical problems.					
7.	Teaching method does not teach me how to transfer the concepts and the skills in new situations and problems.					
8.	Teaching method does not help me in doing mathematical proofs.					
9.	Teaching method introduces the strategies and algorithms for solving the mathematical problems in a simple way.					
10.	Teaching method helps me to explain how the new information relates to previously mastered mathematical skills.					
11.	Teaching method helps me understand the mathematical problem and to explore a solution for it.					
12.	Teaching method leads me to expect the primary solution.					
13.	Teaching method increases my skills in computations.					
14.	Teaching method does not help me to collect data and choose algorithms to organise it in solving problems.					
15.	Teaching method lets enables me to translate the word problems into mathematical problems.					
16.	Teaching method helps me to link the mathematical subjects with different life situations.					
17.	Teaching method increases my ability to use the mathematical skills in solving some of the live applications.					

18.	Teaching method helps me to understand other subjects such as science and geography.					
19.	Teaching method offers a solution for my weakness in solving problems.					
20.	Teaching method promotes my ability to solve mathematical problems in a successful way.					

Part Two
Students' perspectives toward teaching strategies

NO.	The Statements	The Responses				
		SA	A	U	D	SD
1.	I'd like to continue using the same teaching method in mathematics.					
2.	I prefer to use the mathematics teaching method in the other subjects.					
3.	The subjects in mathematics are introduced in an interesting way.					
4.	Teaching method creates a competitive atmosphere.					
5.	I prefer to ask about some ideas in mathematics from my classmates.					
6.	Some of the classmates can explain some points in an easier way than the teacher can.					
7.	I do not hesitate to ask the teacher about any problem I may face in solving problems.					
8.	The teacher can answer all the students' questions within the class.					
9.	There are no major differences in mathematics teaching strategies.					
10.	The teacher links be mathematical problems with different life situations and their applications.					

Part Three
Students' attitudes towards mathematics

NO.	The Statements	The responses				
		SA	A	U	D	SD
1.	Mathematics is a difficult subject and needs a lot of effort to be understood.					
2.	I like teaching mathematics and solving mathematical problems.					
3.	It is possible to simplify the mathematical information in a way that it is easy to be understood.					
4.	I am always afraid of failing in mathematics.					
5.	Mathematics is useful for me to organise my special life situations.					
6.	Mathematics is not related to any other school subjects.					
7.	There are a lot of wide applications in the daily life situations.					
8.	Learning mathematics helps me to solve my problems in the daily life.					
9.	I like mathematics less than I used to.					
10.	Learning mathematics is a wide field for discovery and development.					
11.	Mathematics subject does not stimulate the attention.					
12.	Learning mathematics helps me to be more accurate in the work to think in a logical way.					
13.	I do not like mathematicians or those who work in the mathematical sciences.					
14.	I need always to someone who helps me in learning mathematics in order to success.					
15.	Mathematics is an attractive subject.					
16.	Mathematical concepts are not complex and can be understood.					
17.	I like solving puzzles and games which are solved mathematically.					
18.	I hope to be a mathematics teacher in the future.					
19.	Mathematics is the basis of scientific improvement and modern technology.					
20.	I feel bored when others talk about mathematics in front of me.					

Part Four
Outcomes other than achievement

NO.	The Statements	The Responses				
		SA	A	U	D	SD
1.	My relationship with my classmates is stronger than before.					
2.	I deal with my classmates who are not the same as my social class.					
3.	Cooperation with the classmates is useful for all of us.					
4.	I prefer to solve the mathematical problems by myself without any help from any of my classmates.					
5.	Low achieving students have a chance for success.					
6.	All of the students have equivalent chances in learning and in contributing during the class activities.					
7.	The actual contribution in the class is for the high achieving students.					
8.	Learning disabilities cause a barrier against the development.					
9.	I do not like to deal with low achieving students.					
10.	Choosing my friends depends on their academic achievement.					
11.	I believe that I am valuable and important.					
12.	I am confident to make my decisions by myself.					
13.	I feel that I am not well liked by my peers.					
14.	I feel that I am doing well academically.					
15.	Teaching method goals create peer norms that support high achievement.					
16.	There are incentives that motivate students to try to get each other to do academic work.					
17.	I feel that my classmates do not want me to do my best.					
18.	I believe that my academic success depends on my own effort.					
19.	I feel that my outcomes depend on luck rather than my performance.					
20.	We spend more time working on the academic task than before.					
21.	I do not like the school.					
22.	I like my class and my classmates.					
23.	We spend a waste time in the school.					
24.	I like the cooperative work with my peers.					

25.	I do not deal with my classmates out of the class.					

Part Five
The external factors which may affect the learning and teaching process

NO.	The Statements	The Responses	
		Yes	No
1.	I have a personal computer at home.		
2.	I take tutorial classes in mathematics.		
3.	My family helps me in learning mathematics.		
4.	I study mathematics books other than mathematics textbook.		
5.	I take mathematics assisting classes in educational centres.		
6.	I watch the mathematical educational programmes on the TV.		
7.	I participate in the mathematical activities at school.		
8.	I look at the mathematics puzzles and try to solve their problems.		
9.	I get encouragement from my family to increase my achievement.		
10.	I use the calculator to solve simple calculations.		

Many Thanks For Your Efforts

Appendix Four

Guidance Observation Sheet

Observer:................................
Day / Date: ....
Teacher:.................................
Grade / Class:...........................
No. of Students.........................
Unit / Lesson / Type:....................
...

Teacher's Mathematical Teaching Skills	**Observations and field notes**
Introduction: • Explaining the assignment and the objectives of the lesson. • Presenting the concepts that are needed for the lesson. • Explaining the academic task and the problem to be solved. • Presenting similar and small problems for discussion. • Introducing the lesson in an interesting and exiting way. • Linking between the objectives of the lesson and our daily life situations. • Making connections between mathematical concepts, roles, facts, algorithms and problem solving.	
Exploration and Group Working: • Monitoring the group working. • Encouraging the students to work together. • Helping the group members if they need help. • Asking the group members to monitor their performance, behaviour, and functioning. • Observing and listening to the students ideas, discussions, procedures and strategies for solving the problems. • Providing additional activities for groups that finish more quickly than the others.	

Reflection, Evaluation and Processing: • Group/ students summarising their work and sharing their processes. • Group/ students presenting their solutions. • Evaluating students' achievement. • Providing feedback after evaluation.	
Group Management: • Explaining the positive goal interdependence, the learning task and the expectation for the group, the expected collaborative behaviour, the procedure to follow and the definition of the group. • Making sure of the contribution and the interaction of the students to accomplish their goal and sharing the materials. • Supporting the students to explain, to elaborate and to encourage the students' academic achievement. • Ensuring that students understand that they are individuals accountable for their assignment. • Assigning students into heterogeneous groups. • Encouraging team competition. • Motivating the best team by providing it incentives and rewards. • Assigning students' specific role responsibilities.	
Instruments and Materials: • Structuring the materials and the instructions for the use of the students. • Deciding how to distribute the instructional materials. • Using different and variety instruments. • Indicate which of the following: • Yes No • Textbook • Work Sheet • Manipulative / Games • Quiz / Test • Other (Specify....)	
Students Group Work • Positive interdependent. • Interaction and contribution within students. • Completion of the assignment and the learning task. • Cooperation. • Competition within groups • Communication skills.	

• Distributing the materials and instruments. • Social interaction between students. • Behaviour of the students. • Excitement of the work. • Attitudes of the students.	
Classroom Management: • Organising the classroom physically. • Deciding the size of the learning group.	

Other comments or remarks:..

General Evaluation:...................................

Appendix Five

Guidance Weekly Diary

Points to be observed	Teacher's comments
1. Achieved the objectives of the lessons and mastered the mathematical assignments. 2. The discussion and contribution in solving problems. 3. The cooperation and the interaction between students. 4. Problem solving skills including: - understanding the mathematical concepts and rules - the ability to use the concepts and rules in solving problems - problem solving and its applications - using new mathematical symbols and vocabulary - the ability in mathematical proofs - linking between mathematical subjects 5. The interest and suspense for working. 6. The students' activity. 7. The competition atmosphere. 8. The social relationship. 9. Students attitudes towards mathematics.	

Appendix Six

Students and teachers interviews

a) Students' Interviews

First of all I want to thank you for taking part in a follow up interview. Moreover, I want to assure you that your response will remain completely anonymous and that data collected will be used for the scientific research objectives only. Your name will not be kept on the records of the interview.

The interview's questions with students

1. Are you interested in mathematics lessons and look forward to them? Is this a new feeling? Why?
2. Do you like mathematics? Why?
3. Are you satisfied and comfortable with the teaching method in mathematics? Why?
4. Would you prefer to continue using this method or return to the previous method / change the method of teaching?
5. Does the teaching method increase the cognitive and the competitive atmosphere? If yes, how? If no, why?
6. Do you think that your achievement is getting better? Why?
7. Have you noticed that the teaching method affects your ability in solving problems? If yes, how? If no, why?
8. Do you think that your teacher applies the mathematics teaching method in a good way? Should your teacher continue using the teaching method or return to the previous method / apply a new method of teaching?
9. Does the teaching method affect the other non-academic achievements? For example, the relation between you and your classmates, your personality, your liking to school and to your classmates, and so on.
10. Does the teaching method highlight the importance of mathematics and its effect on your thinking and in solving problems in different new daily life situations? If yes, how? If no, why?
11. What are the advantages and disadvantages of this teaching method?

Thank you for your cooperation

a) Teachers' Interviews.

First of all I want to thank you for taking part in a follow up interview. Moreover, I want to assure you that your response will remain completely anonymous and that data collected will be used for the scientific research objectives only. Your name will not be kept on the records of the interview.

The interview's questions with teachers

1. How important do you think it is that the teaching methods you adopt has a real effect on learning if it used in a correct way?
2. Do you consider the teaching method you applied as a rational strategy in teaching mathematics? Why?
3. Have you noticed that the teaching method affects on the students' performance? If yes, how? If no, why?
4. Do you think that the method of teaching enhances promote problem solving skills in mathematics for the students? If yes, how? If no, why?
5. Can you describe the atmosphere you feel in your class during teaching and learning? Do you think that this atmosphere progresses the learning process in mathematics?
6. Does the teaching method offer students who have disabilities or who are low achieving a chance to help them to succeed?
7. Do you notice that the students' progress and improvement depend on their achievement? Alternatively, does the method affect differently according to their levels and ability?
8. How confident are you of your understanding you feel as a teacher to use cooperative learning effectively as a teaching method?
9. Are you satisfied with the training programme you had in how to use the cooperative learning in mathematics classroom? What are the advantages and disadvantages of this training programme? / Would you prefer to take an extra training courses in teaching strategies in mathematics? Why?
10. How positively is the learning improved by the cooperative learning method?
11. Would you like to continue using the teaching method in the experiment in all stages you teach? Why?
12. How do you feel towards this teaching method of instruction in mathematics?
13. Did you observe any changes in the students' activities, relations, personalities, attitudes toward mathematics and their social skills? If yes, Is this new behaviour? Can you explain the reasons? If no, can you explain the reasons?
14. Have you heard or noticed that the students agree or disagree dealing with the / new teaching method?

15. Do you think that our curriculum is prepared in a good way such that you can apply any teaching method for this curriculum? If yes, why? If no, what are your suggestions?
16. What are the advantages and disadvantages of the teaching method you apply?

Thank you for your cooperation

Appendix Seven

Teachers' Training Programme

Session:	**One.**
Date:	Sunday 18/3/2001.
Time:	7:30- 9:30 am male school. 12:30- 2:30 pm female school.
Topic:	Introduction to the training programme.
Aims and Objectives:	- To inform teachers of the aims and objectives of the research. - To inform teachers about the procedures of the experiment. - To provide teachers with some research instruments.
Procedures and Activities:	- Welcome and thanks. - Explaining and discussing the objectives of the study. - Encouraging teachers to cooperate in applying cooperative learning in an effective way as much as they can. - Providing teachers with: 1. A copy of the syllabus for training teachers in how to use cooperative learning strategies in the mathematics classroom to be used during the training programme as a written form that might facilitate them in the implementation of the experiment. 2. A copy of the pre-test and its answer key. 3. A copy of the organisation weekly diary. - Arranging with teachers to apply the pre-test on Thursday 22/ 3/ 2001 and telling the students to pay their attention to the exam and to prepare themselves to apply it.

	- Answering any questions. - Thanks and leaving.
<u>Session:</u> Date:	**<u>Two.</u>** Monday 19/ 3/ 2001.
Time:	7:30- 9:30 am male school. 12:30- 2:30 pm female school.
Topic:	What is cooperative learning?
Aims and Objectives:	- To provide teachers with a real meaning of cooperative learning (see chapter five, pp78-79). - To inform teachers about the world wide research findings of the advantages of cooperative learning and the expected outcomes in the cognitive and non-cognitive domains. - To persuade teachers about the rationality for using cooperative learning in the mathematics classroom.
Procedures and Activities:	- Asking teachers as a group to define cooperative learning and their beliefs about its components and advantages. - Discussing teachers' answers and comments and providing them with a good definition of cooperative learning. - Discussing and explaining the advantages of cooperative learning specially in mathematics and the expected outcomes in the cognitive and non-cognitive domains, for example: its effects on students' behaviour like self esteem, attitudes toward mathematics, acceptance of mainstream and classmates, time on task, liking of class and classmates, cooperation and acceptance of others. - Discussing and explaining the rationality for using cooperative learning in mathematics regarding the motivational and cognitive theories and establishing what makes cooperative learning work in the mathematics classroom (see chapter five, pp.80-81). - Thanks and leaving.

Session:	**Three.**
Date:	Tuesday 20/ 3/ 2001.
Time:	7:30- 9:30 am male school 12: 30- 2:30 pm female school.
Topic:	The principle components in cooperative learning.
Aims and objectives:	- To provide teachers with the common elements in all cooperative learning strategies. - To provide teachers with the basic components of cooperative learning.
Procedures and activities:	- At the beginning of this session the researcher discussed the elements of cooperative learning strategies as mentioned in the syllabus (see chapter five, pp. 79-80). - The researcher discussed the basic components of cooperative learning such as: individual accountability, group task, task specialisation, social/ task skills development, equal opportunities for success, team competition, adaptation to individual needs, a positive interdependence. - Asking teachers as a group to discuss between themselves and imagine how they may satisfy these elements and components. - Discussing all the ideas and comments and providing them with several techniques and strategies to satisfy these components. They were then discussed in detail in the next sessions.
Session:	**Four.**
Date:	Wednesday 21/ 3/ 2001.
Time:	7:30- 9:30 am male school. 12:30- 2:30 pm female school.
Topic:	When to use cooperative learning in the mathematics classroom.
Aims and Objectives:	- To provide teachers with different opportunities and activities that can be enhanced by using cooperative

	learning strategies in mathematics (see chapter five, pp. 81-83).
Procedures and Activities:	- Asking teachers as a group to identify some opportunities and activities that can be enhanced by using cooperative learning methods. - Discussing and explaining teachers' comments and classifying them into general types for these lessons, such as: problem solving, development, enrichment activities, homework and test review. - Discussing and explaining each part separately and how to apply cooperative learning strategies within these lessons as was mentioned in the syllabus. - Using the syllabus to discuss the example for using cooperative learning in the developmental lesson (see appendix eight) to provide teachers with an exciting example of worksheets that can be prepared for use by the group work. - Concentrating during discussion about some components of cooperative learning that can be applied and highlighted by using these types of lessons. - Answering any questions. - Thanks and leaving.
<u>Session:</u>	**<u>Five.</u>**
Date:	Thursday 22/3/2001.
Time:	7:30- 9:30 am male school. 12:30- 2:30 pm female school.
Topic:	The teacher's role.
Aims and Objectives:	- To explain the most important rules that must be applied during the implementation.
Procedures and Activities:	- Explaining and discussing in detail each of all the teacher's role that are declared in detail in the syllabus. The roles concentrated on: explaining the assignment and the group goal, structuring

	the material, monitoring students' interaction work, encouraging satisfying the individual accountability, assigning students to heterogeneous groups, organising the classroom physically, monitoring group work, evaluating students, providing feed back, monitoring student behaviour, motivating students (see chapter five pp. 83-85). - Answering any questions. - Thanks and leaving.
<u>Session:</u>	**<u>Six.</u>**
Date:	Sunday 25/3/2001.
Time:	7:30- 9:30 am female school. 12:30- 2:30 pm male school.
Topic:	The teachers' decisions.
Aims and Objectives:	- To explain the teachers' dicisions in implementing the cooperative learning.
Procedures and Activities:	- Explaining and discussing the teachers' decisions on: (see chapter five, pp. –85-89) 1. Deciding on the size of the learning group. 2. Assigning students to groups including: making copies of group work reported, ranking students, deciding on the size of the learning groups, assigning students to groups and filling out group reports. Within the discussion the researcher used the forms for assigning students to groups and group weekly report prepared in the syllabus (see chapter five, figures 5.1 and 5.2). - Asking teachers to assign the students involved in the experiment to their groups and prepare the group weekly report for them use for the purpose of the study (at home). - Discussing and explaining reasons for assigning students to their heterogeneous groups, teachers must take care of other things than achievement like, students' behaviour, students communication skills, and so on...

	- Answering any questions. - Thanks and leaving.
Session:	**Seven.**
Date:	Monday 26/3/2001.
Time:	7:30-9:3 am female school. 12:30- 2:30 pm male school.
Topic:	Continue (the teachers decisions).
Aims and Objectives:	- To continue explaining teachers' decisions in implementing the cooperative learning.
Procedures and Activities:	- Discussing and answering any questions related to assigning students to groups and completing the weekly reports. - Explaining and discussing the following: 1. Arranging the classroom physically. 2. Deciding how to distribute the instructional materials among groups. 3. Planing whether or not to assign students specific role responsibilities (task specialisation). - Asking teachers as a group to imagine how they may start the implementation. - A summary discussion and assessment about the implementation of the experiment.
Session:	**Eight.**
Date:	Tuesday 27/3/2001.
Time:	7:30-9:30 am female school. 12:30-2:30 pm male school.
Topic:	Teaching cooperative problem-solving.
Aims and Objectives:	- To explain how to teach cooperative problem-solving.

Procedures and Activities:	- Asking teachers as a group to decide how to teach cooperative problem-solving. - Explaining, discussing and classifying cooperative learning into three major parts (see chapter five, pp. 91-93). 1. Introduction. 2. Exploring and group work. 3. Reflection, evaluation and processing. - Answering any questions. - Thanks and leaving.
<u>Session:</u>	**<u>Nine.</u>**
Date:	Wednesday 28/3/2001.
Time:	7:30- 9:30 am female school. 12:30- 2:30 male school.
Topic:	Samples of activities and lessons in cooperative learning groups.
Aims and Objectives:	- To present several type of samples of activities and lessons to be used in cooperative learning groups. - To train teachers to prepare worksheets for the cooperative learning lessons.
Procedures and Activities:	- Presenting for teachers several types of activities and lessons from different units in the Jordanian mathematics curriculum for the eighth grade as examples of some mathematics lessons that have been adapted for using cooperaive learning groups (see appendix eight). The activities included problem-solving lessons, developmental lessons and unit review. - Explaining and discussing how to prepare problem sheets and how to adapt the contents of the Jordanian curriculum lessons for the need of cooperative learning lessons. - Asking each teacher to choose any lesson and to adapt it for the use of cooperative learning to be

	discussed the next day. - Answering any questions. - Leaving and thanks.
Session:	**Ten.**
Date:	Thursday 29/3/2001.
Time:	7:30-9:30 am female school. 12:30 2:30 pm male school.
Topic:	General review and preparing for experimental implementation.
Aims and Objectives:	- To review all the contents covered in previous sessions. - To give general guidance for the experimental implementation.
Procedures and Activities:	- Collecting the prepared lessons that have been adapted by the teachers. - Discussing the contents, answering questions and giving some comments and advise. - Asking teachers to prepare themselves for starting the implementation as an experiment to be observed by the researcher and giving feedback to overcome any problems which may arise.
The Experimental Implementation.	
Date:	Sunday 1/4/2001 female school. Monday 2/4/2001 male school. Tuesday 3/4/2001 female school. Wednesday 4/4/2001 male school.
Time:	8:00 am - 2:00 pm.
Topic:	Lesson observation, evaluation and feedback.

Objectives:	- To evaluate to what extend the teachers were able to implement cooperative learning strategies. - To provide teachers with feedback to overcome the problems or disadvantages which may negatively affect the implementation of cooperative learning.
Procedures and activities:	- Arranging for classroom visits. - Observing lesson implementation, initial evaluation of writing field notes. - Discussing, giving feed back to overcome problems and disadvantages which arise during the implementation. - Answering any questions and giving suggestions for assessing for the programme. - Meeting students involved in the experiment and encouraging them to cooperate with their teachers for effective implementation to solve their problems in understanding mathematics lessons.

Appendix Eight

Samples of Activities and Lessons for Cooperative Learning Groups

Lesson one (Developmental Lesson)

Unit Title: The Quadrilaterals and the Equivalence Theorems.

Lesson Title: Theorems in Equivalence.

Objectives:

1. To prove theorem (1) which denotes: " The rectangle is equivalent to the parallelism which is union to it in its base and height ".
2. To prove theorem (2) which denotes: " Two parallelisms which are located exactly between two parallel lines and they have the same base are equivalence ".

Materials for Each Group:

- Problem Sheet (1). Fig (4)
- Problem Sheet (2). Fig. (5)
- Two Record Sheet (1). Fig. (6)
- Two Record Sheet (2). Fig. (7)
- Two different coloured rectangles and two different coloured parallelisms for activity(1).
- Four different coloured parallelisms for activity (2).
- Glue.

General Guidelines

- The group members will divide themselves into two sub-groups.
- The teacher will give each group the materials that are prepared for each activity separately.
- The materials must be prepared in a good way to meet the objectives of the lesson according to their areas; the materials to be used in each activity must be the same colour.
- After each group has finished its activity, all the groups within the class will discuss their generalisation until the whole class agrees the general generalisation which represents the theorem that needs to be proved.
- The teacher randomly select a student who will be the spokesperson for a specific group, who has mastered the material, and ask him/her to discuss it for all the class by using the OHP.

Activity one: to prove theorem one

Figure (4): Problem Sheet (1)

Divide your group into two sub-groups. Each subgroup members will participate and help each other to do the following activities.

1. Take one rectangle with one parallelism which have the same colour and try to stick them with the glue such that one side of the rectangle is congruence to the base of the parallelism.
2. Determine the parallel lines on the figure you have got.
3. Determine (on the figure you have got) the base and the height of the parallelism, and the length and the width of the rectangle and denote them by b, h, l, and w, respectively.
4. Calculate the area of the rectangle and the parallelism in terms of b,h,l, and w and record them on the record sheet.
5. Find the relationship between (b and l), (h and w).
6. What do we call these two geometric shapes?
7. Compare your results with the rest of your group members and discuss your solutions.
8. Write down the last generalisation.

Figure (6): Record sheet (1)

Stick the figures in this space.

The area of the parallelism = ...

....

The area of the rectangle = ...

....

The relationship (b and l): ....

The relationship (h and w): ....

These geometric shapes are ....

The generalisation: ....

....

....

<u>Activity two: to prove theorem two</u>

Figure (5) : Problem sheet (2)

Divide your group into two sub-groups. The members of each subgroup will participate and help each other to do the following activities.

1. Take the same two coloured parallelisms and stick them with the glue n the record sheet such that one side of the first parallelism is congruence to one side of the other parallelism and be sure that they are located between two parallel lines.
2. Determine the parallel lines on the figure you have got.
3. Determine and label the base and the height for each parallelism and denoted them by b1, h1, b2, and h2, respectively.
4. Calculate the area of each parallelism in terms of b1,h1, b2, and h2 and record them on the record sheet.
5. Find the relationship between (b1 and b2) and between (h1 and h2).
6. What do we call these two parallelisms?
7. Compare your results with the rest of your group members and discuss your solutions.
8. Write down the last generalisation.

Figure (7):Record sheet (2)

Stick the figures in this space.

The area of parallelism 1 = ...
....

The area of parallelism 2 = ...
....

The relationship (b1 and b2) ....
The relationship (h1 and h2) ....

The two parallelisms are ....

The Generalisation:..
....
....

Lesson two ((Problem Solving and Developmental Lesson)

Unit Title: Relations and Functions

Lesson Title: Representing the Linear Functions by a Diagram

Objectives

To draw a linear function by a diagram

Materials for each group:

- Report sheet. Fig. (8)
- Record sheet with chart diagram paper. Fig. (9)
- Ruler.

Figure (8) : Problem Sheet

To draw a linear function you must follow the following steps. One student should read the procedures while the rest of your team divides the task, such that all of you participate and contribute to complete your task.

Exercise (1) : To draw the linear function **f (x) = x** follow the following procedures.

1. Choose any three numbers from the domain of the function **f** and record them in the table on the record sheet to represent the values of **x.**
2. Find the value of these numbers under the function **f (x) = x** and record them in the table on the record sheet to represent the values **y = f (x).**
3. Represent the pairs of numbers by points in the table.
4. Label these points on the Cartesian co-ordinate by using the diagram chart sheet.
5. Join these points by using a ruler.
6. What is the graph you have got?

Remark: To represent a linear function it is enough to choose two numbers.

Exercise (2) : Repeat the previous steps to draw the following linear functions:

- **f (x) = 2 x - 1**
- **y = 3**

Figure (9) : Record Sheet

$y = f(x) = x$		
		(x, y)

$y = f(x) = 2x - 1$		
		(x, y)

$y = f(x) = 3$		
		(x, y)

This function is called ……………………..

The straight line is parallel to ………………..and passes throw the point ………….. on the ……….. axis.

The result : ………………………………………………………………

……………………………………………………………

Lesson three (Problem Solving Lesson)

Unit Title : Linear Equations Systems

Lesson Title : Problem Solving Lesson.

(applications by using solving of two linear equations)

Objectives

To solve problems by solving the two linear equations which represent the system of the problem.

Materials for each group

- Problem Sheet. Fig. (10)
- Problem Answer Sheet.

General guidelines

At the beginning of the lesson the teacher must introduce the lesson by solving one or two examples for the students to discuss how to form the equations that represent the problem.

Figure (10): Problem Sheet

You have learned several different methods for solving the two linear equations. Try to solve the following problems by using several methods.

Problem 1

A number consists of two digits. The second digit is greater than the treble of the first digit by one. If we change the position of the two digits, the number will be reduced by 45. What is this number?

Problem 2

Two planes were flown up from an airport in two different directions and at the same height. After 3 hours the horizontal distance between them is 2340 miles. If the speed of one of the two planes is greater than the other by 30 mile/hour, what is the speed of the two planes?

Lesson Four (Homework Review)

Unit Title: Trigonometric Ratios for Angles

Lesson Title: General Review of the Unit

Objectives

To review the application of the trigonometric ratio for angles.

Material for each group

- Problem sheet for each student. Figure (11)

General Guidelines

- The students are to complete the problem sheet as a homework assignment. On the next day, the students in the class must agree on the solutions to the problems. A group gets credit for the correct solution only if any person who is called on by the group presents a correct explanation of the problem to the class.
- Similar problem sheets can be made to review work in other areas of the curriculum.

Figure (11) : Problem Sheet

1. Complete the given exercises at home. State all theorems and generalisations you used in each case
2. Bring your completed assignment to class tomorrow for group discussion.
3. When the members of your group have agreed on the last solution for each problem, submit one set of solutions for your group.
4. Each person must be able to explain any of the group's solutions to the whole class.

Excercises

1. **abc** is a right triangle at **b**. **ab** = 12 cm., **bc** = 15 cm. Find out **sin(a)**, **cos(a)**, and **tan(a)**.
2. If **tan(x)** = 12 / 5 where **x** is an acute angle. Find $\sin^2 x + \cos^2 x$.
3. If $\sin^2 x$ = 1 / 4, use the trigonometric tables to find the value of the angle **x.**
4. Let **x** be an acute angle where **sin x** = 5 / 13. Find **sin (90 - x)** and **tan (90 - x).**
5. A garden its shape is a rectangle. Its length is 50 m. if the diagonal of the garden makes an angle equal **64°** with its smallest side. Find the width of the garden.

Lesson five(Developmental and Problem Solving Lesson)

Unit title: Probability.

Lesson Title: The Event.

Objevtives

1. To understand the definition of the event.
2. To classify the kinds of events.
3. To understand the operations of the events.
4. To represent the operations of the events by a vin-diagram.

Materials for each group

- Problem sheet (1) for activity one. Fig.(12)
- Problem sheet (2) for activity two. Fig. (13)
- Answer sheet (1) for activity one. Fig. (14)
- Answer sheet for activity two.
- Different colours for activity two.
- Circular disk for activity two.
- Pointer for activity two.

General guidelines

At the beginning of the lesson the teacher must introduce the lesson by solving one or two examples for the students to discuss the main ideas in order to satisfy the objectives of the lesson. After that the problem sheet will be distributed for all groups within the class to be solved as group work.

Figure (12): Problem Sheet (1)

Activity one

In an experiment to choose an integer number from the numbers 2, 3,4,5,6 . If E1, E2, E3, and E4 denotes the events, such that :

- E1: The even numbers.
- E2: The odd numbers.
- E3: The prime numbers.
- The factors of the number 6.

1. Work out with your group to complete table (1) on your answer sheet. You must find:

- each event (**E**) and its kind
- the complement of the event (**Ē**) and its kind
- the intersection of the event with its complement (**E ∩ Ē**)
- the union of the event with its complement (**E U Ē**).

2. Represent the following events by a vin-diagram.

- **E1 ∩ E4.**
- **E1 ∩ E2.**
- **Ē3.**

After you have finished your table discuss with your group members your results and try to find a generalisation.

Figure (13): Problem Sheet (2)

Activity two

All the students in each group will participate to complete the following task. Each student will do one of the following activities.

1. Divide the circular disk into 8 equal parts.
2. Number the parts from 1 to 8, respectively.
3. Fix the pointer in the centre of the disk such that the pointer can move quickly.

If we let the pointer stop by itself after we push it, what are the events which denote the following:

- **E1**: The stopped of the pointer at an odd or prime number.
- **E2**: The pointer not to stop at an even number.

Record your answers on the answer sheet.

Figure (14): Answer Sheet

The Event E		Kind	The Complement $\bar{E}$		Kind	$E \cap \bar{E}$	$E U \bar{E}$
E1			$\bar{E}1$				
E2			$\bar{E}2$				
E3			$\bar{E}3$				
E4			$\bar{E}4$				
E5			$\bar{E}5$				
E6			$\bar{E}6$				

The generalisation: $E \cap \bar{E}$ = ...

$E \cup \bar{E}$ = ...

$E1 \cap E4$

$E1 \cap E2$

$\bar{E}3$

Appendix Nine

Additional Statistical Tables

a) Descriptive statistics for paired samples test.

		Paired Differences					
Group	Correlated pairs	Mean	Std. Deviation	Std. Error Mean	95% confidence interval of the difference		t
					Lower	Upper	
Cooperative female (N = 86)	Pair 1 PREA & POA	-3.5814	4.4204	.4767	-4.5291	-2.6336	-7.513
	Pair 2 PREB & POB	-6.0000	5.7558	.6207	-7.2340	-4.7660	-9.667
	Pair 3 PRET & POT	-9.7326	9.0948	.9807	-11.6825	-7.7826	-9.924
Cooperative male (N = 87)	Pair 1 PREA & POA	-2.4713	4.1898	.4492	-3.3642	-1.5783	-5.502
	Pair 2 PREB & POB	-2.1264	3.5790	.3837	-2.8892	-1.3636	-5.542
	Pair 3 PRET & POT	-4.1379	5.4307	.5822	-5.2954	-2.9805	-7.107
Traditional female (N = 90)	Pair 1 PREA & POA	- .3222	2.4851	.2620	-8.427	.1983	-1.230
	Pair 2 PREB & POB	.2444	3.1133	.3282	-.4076	.8965	.745
	Pair 3 PRET & POT	- .44E-02	2.8121	.2964	-.6334	.5445	- .150
Traditional male (N = 85)	Pair 1 PREA & POA	.1765	6.5668	.7123	-1.2400	1.5929	.248
	Pair 2 PREB & POB	1.2235	4.5732	.4960	.2371	2.2099	2.467
	Pair 3 PRET & POT	1.6353	10.0224	1.0871	-.5265	3.7971	1.504

* Significant ($\alpha < 0.05$).
N : number of students.
df: degree of freedom.
t: t value.

		d f	Sig. (2-tailed)
Cooperative female (N = 86)	Pair 1 PREA & POA	85	.000 *
	Pair 2 PREB & POB	85	.000 *
	Pair 3 PRET & POT	85	.000 *
Cooperative male (N = 87)	Pair 1 PREA & POA	86	.000 *
	Pair 2 PREB & POB	86	.000 *
	Pair 3 PRET & POT	86	.000 *
Traditional female (N = 90)	Pair 1 PREA & POA	89	.222
	Pair 2 PREB & POB	89	.458
	Pair 3 PRET & POT	89	.881
Traditional male (N = 85)	Pair 1 PREA & POA	84	.805
	Pair 2 PREB & POB	84	.016 *
	Pair 3 PRET & POT	84	.136

* Significant ($\alpha < 0.05$).
N : number of students.
t: t value.

b) **Multivariate analysis of variance of the students' response in the two experimental grou towards the parts of the questionnaire according to the interaction between teaching meth and gender.**

Source of variance	Dep. Var.	Sum of squares	D f	Mean Square	F	Sig.
Corrected Model	P1 Part1	65.069 a	2	32.534	59.089	.000
	P2 Part2	16.418 b	2	8.209	23.377	.000
	P3 Part3	15.077 c	2	7.538	11.791	.000
	P4 Part4	5.398 d	2	2.699	9.142	.000
	P5 Part5	3.412 e	2	1.706	7.569	.001
	PT	27.421 f	2	13.710	40.693	.000
Intercept	P1 Part1	819.303	1	819.303	1488.020	.000
	P2 Part2	545.811	1	545.811	1554.363	.000
	P3 Part3	528.083	1	528.083	825.994	.000
	P4 Part4	494.492	1	494.492	1674.962	.000
	P5 Part5	41.754	1	41.754	185.218	.000
	PT	665.811	1	665.811	1976.139	.000
Method * Gender	P1 Part1	65.069	2	32.534	59.089	.000
	P2 Part2	16.418	2	8.209	23.377	.000
	P3 Part3	15.077	2	7.538	11.791	.000
	P4 Part4	5.398	2	2.699	9.142	.000
	P5 Part5	3.412	2	1.706	7.569	.000
	PT	27.421	2	13.710	40.693	.000
Error	P1 Part1	188.305	342	.551		
	P2 Part2	120.092	342	.351		
	P3 Part3	218.651	342	.639		
	P4 Part4	100.967	342	.295		
	P5 Part5	77.098	342	.225		
	PT	115.228	342	.337		
Total	P1 Part1	4703.000	345			
	P2 Part2	4057.000	345			
	P3 Part3	4188.000	345			
	P4 Part4	4156.000	345			
	P5 Part5	729.000	345			
	PT	4535.000	345			
Corrected Total	P1 Part1	253.374	344			
	P2 Part2	136.510	344			
	P3 Part3	233.728	344			
	P4 Part4	106.365	344			
	P5 Part5	80.510	344			
	PT	142.649	344			

* Significant ($p < 0.05$)
Dep. Var.: Dependent variable.
F: F value.
d f : Degree of freedom.