HAIGAZIAN UNIVERSITY

THE EFFECTS OF A PROFESSIONAL DEVELOPMENT PROGRAM ON THE IMPLEMENTATION OF MATHEMATICAL PROBLEM SOLVING IN THE CLASSROOM

By
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ABSTRACT

Problem solving in school mathematics has been a priority in mathematics education since 1980, and while it has been a key area of focus, students continue to score poorly on test questions that measure mathematical problem- solving skills. With the emphasis on standardized testing globally, there is a real need to find a solution for this continuing poor student performance in mathematics. Most research completed in the last 25 years in the area of mathematical problem solving has focused on student achievement, and little attention has been paid to the role of the teacher in regards to student achievement. One approach to improving student problem solving skills is to implement reform to educate teachers in mathematical problem-solving skills. With the current shortage of qualified mathematics teachers, and teachers with certifications other than teaching mathematics, it is necessary to determine effective ways of providing professional development for teachers in critical areas of mathematics such as problem solving.

The purpose of this study was to determine if a professional development program that taught mathematical problem-solving skills affected teachers' performance. Did these teachers provide problem-solving opportunities more frequently than teachers who had not participated in the program?

This study compared two groups of teachers, those who participated in a professional development program, and a group of teachers who did not participate in the professional development program. The area addressed was the use of the problem solving model and strategies. The results of this study suggested that teachers who participated in the professional development program incorporated problem solving more frequently than teachers who had not participated in the program. The study supported existing research, that if educational reform is to be accomplished, it requires well-constructed professional development programs and long-term support.

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CHAPTER ONE

INTRODUCTION

A. Statement of the Problem and Its Background

The issue of problem – solving has been a major focus of Mathematics education. The new curriculum which was implemented in Lebanon in 1997 tried to instill changes in teachers' pedagogy about problem solving when it called for a student – centered classroom and critical thinking. Even though the numerous research in the U S during the last quarter of a century attempted to offer a more constructive approach to problem -solving teaching, students' performance in mathematical problem – solving is still poor (Mullins, el.al.2001). Student achievement in problem – solving has been addressed in most research , but researchers suggest that the role of the teacher has been neglected(Lester,1994; Simpson & Jackson,1997).Most of the research regarding this issue have been conducted in the West, more specifically , in the U S A .No research has been found by this researcher anywhere in the Middle East. In interviews with Lebanese administrators in the Beirut area, all stated that one of the weakest elements in the curriculum is problem- solving; specifically, mathematical problem solving. However, all the administrators said that they were unsure of the reasons for this problem. Some were convinced that it is due to language (being taught in English when Arabic is the mother tongue); while others posited that it is teachers who are not able to teach problem- solving skills because they have not been trained properly in this area. Since there is no evidence for either argument, the following research will attempt to provide answers to some of the questions being raised on "problem-solving".

English, et. al. (2002) suggests that more research needs to be conducted in the areas of teacher education and teacher professional development that can facilitate student access to powerful mathematical ideas. They state that assessing teachers' instructional growth presents great challenges, and that the assessment instruments up until now have been poorly aligned with modern views of the nature of mathematics, problem solving, learning and teaching. Gains in student achievement are only one of many factors that should be considered, and given the variety of student-teacher encounters, and the strengths and weaknesses of the teachers themselves, information relying solely on student results is incomplete. In order for the field to move forward, research on mathematical problem solving needs to examine the teaching and learning processes (Jonassen, 2000a; Lester, 1994). Smith (2001) suggests that research based on student achievement is necessarily a long range project, but research on changes in teachers' classroom practices can effectively and efficiently give insight into future changes in learning outcomes for students. Responding to the concern the nation had for improving student achievement, the National Council of Teachers of Mathematics (NCTM, 1989, 2000) in the USA developed guidelines for school mathematics in general, and teaching mathematical problem solving in particular. Data are needed to explain variability of teacher performance, and to validly assess the degree to which teachers have implemented the NCTM guidelines (Grouws & Schultz, 1996). Focus on the improvement of problem-solving achievement without taking into account the effect of the teacher has not been sufficient (English, 2002).

B. The Implications of Mathematical Problem-Solving in Educational Reform

A strong movement for reform of mathematical problem solving began in 1980 (Goldin, 2002; Huetinck & Munshin, 2000). The NCTM, in response to the unsuccessful "New Math" and "Back to Basics" movements of the 1960's and 1970's, determined that computational competency alone was not sufficient to equip students to be successful in academic situations that depended on mathematical reasoning. Students needed to be able to apply skills in problem-solving situations Huetinck & Munshin, 2000).

In 1980, the National Council of Teachers of Mathematics published *An Agenda for Actions'. Recommendations for School Mathematics of the 1980* guidelines that stated that problem solving and the development of problem-solving ability must be the focus of school mathematics. *The Agenda for Action* (NCTM, 1980) stated that mathematics applications should be tied to real-world problems, using computational skills in unexpected, unplanned settings. This document also suggested that educators give priority to the identification and analysis of specific problem-solving strategies. The NCTM recognized the need to develop appropriate curricular materials to teach problem solving for all grade levels and considered problem solving to be essential to the day-to- day living of every citizen. *The Agenda for Action* (NCTM, 1980) stated that true problem solving power required an understanding not only of particular skills and concepts, but also an understanding of the relationships of those concepts to actual problem-solving situations and maintained that there was a direct relationship between problem solving in the mathematics classroom and problem solving in other parts of our lives.

The national guidelines for school mathematics in the 1990s again incorporated problem solving as a major focus in school mathematics, permeating the entire program, and providing the context in which mathematical concepts and skills would be learned. These standards were written in response to a growing concern that school mathematics was still be not successful in raising the achievement levels of American students (Huetinck& Munshin, 2000).

The *Principles and Standards for School Mathematics* (NCTM, 2000) maintained the focus on problem solving, stating that problem solving is a hallmark of mathematical activity and a major means of developing mathematical knowledge. The NCTM again described problem solving as a tool that cuts across all content areas and should be interwoven into the curriculum (NCTM, 2000). The *Principles and Standards for School Mathematics* (NCTM,

2000) suggested that students should know and be able to apply a variety of appropriate strategies to solve problems, and to monitor and reflect on the process of mathematical problem solving.

Sowell and Zambo (1997) stated that teachers have an awareness of guidelines for reform, although they may not have implemented them in their classrooms. Teachers are not able to meet the challenge of teaching mathematics in new and unfamiliar ways without support (Smith, 2001; Tapin & Chan, 2001).

Cohen and Ball (1990) in their study of the implementation of reforms in California schools noted that the guidelines are implemented in random pieces and are widely open to interpretation. Spillane and Zeuli (1999) also found the implementation of reform in the mathematics classroom to be uneven. So, even with the established guidelines by the National Council of Teachers of Mathematics, these reforms have not been well established. It seems that while excellent suggestions for the teaching of mathematical problem solving may have been put forth, implementation of these teaching strategies varies considerably. Furthermore, Beasley (2000) pointed out that standardized tests have the potential to sidetrack genuine reform efforts. In order for teachers to implement the reforms and adapt a problem-solving approach in the mathematics classroom, support systems and effective professional development programs must be developed (Smith, 2001).

Part of the difficulty of establishing a mathematics classroom oriented towards problem solving is that there has not been a clear consensus of what problem solving is (Jonassen, 2000a). The definition has evolved over time, as the NCTM standards have continued to be refined and adjusted to meet the needs of education today.

C. What is Problem Solving?

Often, mathematical exercises are referred to as "problems." Mathematical exercises that can be solved by mechanical application of a rule that has just been presented are not considered problems in the context of this study. According to Krulik and Rudnick (1989), problem solving is a process; the means by which an individual uses previously acquired knowledge, skills, and understanding to satisfy the demands of an unfamiliar situation. The designation of "problem" implies that the individual is being confronted by a situation he or she does not recognize. A situation cannot be considered a problem once it has been modeled or can be solved by a simple application of a recently learned algorithm. Problem solving requires that the student be able to 1) understand the problem, 2) form a plan for solving the problem, 3) implement the plan and 4) reflect on the reasonableness of the solution (Polya, 1962). This four step model first suggested by George Polya has become the model used by mathematics educators since 1945 (Van de Walle, 2004).

Mathematical problem solving is a higher level thinking skill, and was previously considered an activity only suitable for more capable students. Since 1990, there has been a shift from emphasis for mathematics for the few, to mathematics for all students (NCTM, 2000). The prevailing belief in school mathematics today is that opportunities to learn mathematics at all levels are desirable and possible (NCTM 2000). George Polya whose work in problem solving has become the standard model in this area, (Van de Walle, 2004), suggested a more comprehensive view. Polya believed that the major aim of education is to develop intelligence and to teach young people to think, that learning mathematics insightfully would yield more long lasting results and, that students would not remember mathematical information unless they were taught how to use it (Polya, 1962). Furthermore, Polya (1962) believed that the same mathematics should be taught to all students. This viewpoint is characterized by the "Mathematics for All" movement that is currently underway in the USA. Because of the current emphasis on mathematics for all in American schools, it is necessary to find effective means of teaching problem-solving skills to students with a wide range of abilities and backgrounds. Recent studies have suggested that a constructivist, problem-solving approach to teaching mathematics has improved student achievement (Hickey, Moore, & Pellegrino, 2001). Boaler (2002) found that reform-based education has had a positive influence on resolving issues of equity in the classroom. As the nation is concerned with developing mathematical skills for all students it seems that a problem-solving approach in the classroom can have a positive impact. If more can be learned about the actual process of teaching problem solving in classrooms, then better professional development programs can be designed.

D. The Issue

While problem solving has been a major objective of mathematics education since the 1980s (Huetinck & Munshin, 2000), and many programs have been implemented and much research has been done in reference to mathematical problem solving, more effective ways of teaching problem solving are still needed, as test results at the international, national, state and local levels indicate. At the international level, the United States, although a world power, is not among the top nations in mathematical achievement (Mullis et al. 2001). While there are problems in comparing the United States results to those of other nations, as the educational systems of these countries differ, the data are compelling and cannot be ignored (NCTM, 1990).

The International Association for the Evaluation of Educational Achievement, independent international cooperative of national research institutions and government agencies has conducted two recent assessments of mathematics and science achievement for participating countries. In 1995, the Third International Mathematics and Science Study

(TIMSS) compared the academic achievement in mathematics and science in 45 countries. In this first study, the United States was ranked 28th in mathematics performance. The top five performing countries were Singapore, Korea Japan, Hong Kong and French speaking Belgium. In the 1999 study, four years later, the United States again ranked in the middle of the achievement distribution for mathematics performance. The top five performing countries in 1999 were Japan, Singapore, Republic of Korea, Chinese Taipei and Hong Kong SAR (Mullis, et al, 1999).

An analysis completed at the time of the TIMSS study in 1995 stated that the U S mathematics classes required less high-level thought than classes in Germany and Japan. The typical goal of U S mathematics teachers was to teach students how to do something, while the goal of Japanese teachers was to help them understand mathematical concepts (Peak, 1996). Success with multi-step problems and applications requiring higher level thinking skills was limited even for students from high performing countries. (Beaton, Mullis, Martin, Gonzales, Kelly, & Smith, 1996).

The Third International Mathematics and Science Study-Repeat (TIMSS-R) report stated that higher mathematical achievement is obtained when teachers emphasize reasoning and problem-solving activities. In Japan, the top performing nation, about half of the students had teachers who reported a high degree of emphasis on reasoning activities in their mathematics classes more than any other country (Mullis et al, 2001). Martinez (2000), in his discussion of the TIMSS report, commented that Japanese teachers' goals closely resembled the goals of the NCTM reform movement, and Japanese students frequently engaged in reform-recommended activities, whereas there is a greater emphasis on skill acquisition in American classrooms.

The TIMSS-R report stated that teachers in the United States may be overconfident about their preparation to teach eighth grade mathematics. While 87% of surveyed teachers reported that they felt well prepared, test results do not support that perception (Mullis et at, 2001).

Not only did the United States perform poorly at the international level, similar results were reported at the national level. *The Nation's Report Card: Mathematics 2000* (National Center for Educational Statistics, 2000) shows the average eighth grade scores to be 275 out of a possible 550 points on a national exam, the National Assessment of Educational Progress (NAEP). This is the highest score achieved in the previous four years (Braeswell, Lutkus, Grigg, Santapau, Tay-Lin, & Johnson, 2000). This exam places students in one of four categories: below basic, basic, proficient, and advanced. The criteria for each category are as follows: At a basic level, the student should be able to determine which of available data are necessary and use them in problem solving, a level achieved by thirty three per cent of the students. Thirty four per cent of the students were rated as below basic. Students with a proficient rating was achieved by 22% meant that students should be able to demonstrate an understanding sufficient for problem solving in practical situations. This student should be able to make conjectures, defend ideas, give supporting examples, and understand connections between fractions, percents, decimals, algebra and functions. At the advanced level which was achieved by only 5%, meant that a student should be able to consider the reasonableness of an answer, be expected to use abstract thinking to create unique problem-solving techniques, and explain reasoning processes underlying their conclusions (Braeswell, Lutkus, Grigg, Santapau, Tay-Lin, & Johnson, 2000). Student achievement in the area of mathematical problem solving still needs to improve. In order to do so, it will be necessary to improve the classroom teachers' skills in teaching and modeling mathematical problem solving. It will only be through the teachers that the goal of improving student problem-solving abilities will be accomplished (Thompson,. 1989).

E. Need for the Study

Much of the research in mathematical problem solving has focused on students and has neglected the effect of the teacher (English,. et a!., 2002; Jonassen, 2000a; Simpson & Jackson,. 1997). In a meta-analysis of 487 studies in the area of mathematical problem solving covering the period from the1920's through the 1980s, only 10 articles pertained to teacher training, and this was not in reference to content area (Hembree, 1992). Jonassen (2000) contends that not enough attention has been paid to the instructional model and that we still have not adequately determined a way to teach students to be successful problem solvers. Lowery (2002) also suggests that as teachers are the means by which reform is accomplished, more research is necessary to understand what type of knowledge and level of knowledge teachers need to become effective in the classroom.

Chapman (1997) stated that teaching is a human activity that cannot be defined independent of the people involved in doing it, and that the teacher needs to be considered as a principal research subject, not as a constant. The lack of information on how teachers approach problem solving could be one of the reasons there has not been much success in improving the teaching of problem solving.

Polya (1962) considered the teacher to be the key. Only the teacher could determine the appropriate problems and the appropriate amount of guidance for a particular class. Bringing about change in what goes on in mathematics classrooms depends on individual teachers changing their approach to teaching (Grouws & Schultz, 1996).

Much of the research in which the teacher has been the focus has used standardized achievement test results to evaluate teacher problem-solving activity. these types of studies do not address the complexity of the teaching environment (Schoenfeld, 2002; Jonasson, 2000a; Shavelson, et al., 1989).

Even though the national trend is toward increasing the use of standardized testing to assess student performance, there is still a need to adequately identify if and how teachers are implementing effective techniques for teaching mathematical problem solving, as student performance has continued to lag behind. The few studies that have investigated the role of the teacher have focused either on the classroom learning environment, professional development with regard to the NCTM guidelines, or mathematical problem solving as perceived and practiced by teachers without consideration of their educational background or professional development. The role of the teacher has been neglected.

F. The Purpose of the Study

The purpose of this study is to determine the effectiveness of a professional development program designed to increase both content and pedagogical knowledge in the area of mathematical problem solving. The role of the teacher is explored to determine if the information presented in any of the professional in-service training is implemented in the classroom, and to what extent it is being implemented.

This study will differ from previous studies in the following ways:1) it is conducted in a developing society, 2) there have been few studies that involve the comparison of a trained group of teachers with those untrained in the area of mathematical problem solving, 3) this study is concerned with two dimensions of professional development: content area training, as well as workshops given as in-service training in mathematical problem solving; and 4) teachers are the focus of the study. Previous studies have concentrated on student achievement and have not studied the role of the teacher as being an important factor influencing student achievement.

This research will try to assess possible differences between teachers who received training in mathematical problem-solving content and pedagogy and those not trained in problem-solving content and pedagogy in the following areas first, the type of mathematical problems used to cover competencies like expressing ideas in mathematical language, shifting from one mode of representation to another, using various types of reasoning to solve a problem, knowing how to choose the correct procedure for solving a problem, and validating and interpreting results. Second, the grade level appropriateness of the test. And third the abilities of the students to solve mathematical problems according to the four steps of the problem-solving process, as suggested by George Polya. The steps are understanding the problem, devising a plan, carrying out the plan, and looking back at the problem and the answer to know what the student did to get there.

G. Definition of Terms

Mathematical Exercise: An exercise is a problem that can be solved by the mechanical application of a rule that has just been presented (Baroody, 1993).It could be a word problem that can be solved by translating the words of the problem into a mathematical sentence, and then applying an algorithm to solve (Hyde&Hyde, 1991).

Routine Problem-Solving Problem: A routine problem is a situation for which the solution is contextually driven and connected to mathematics concepts. The solution would require the student to draw on his or her mathematical skill set, and is not merely a translation of a sentence into a mathematical sentence. Examples of this type of problem include area, perimeter, volume, Pythagorean Theorem, and percent and fraction problems, as long as they are not translated problems (Hyde&Hyde, 1991).

Non-routine Problem: A non-routine problem has a non-algorithmic solution (Hyde&Hyde, 1991).Puzzle problems would be an example of this type of problem.

Problem-solving Strategy: A problem-solving strategy is an approach used to solve a problem. Looking for a pattern, drawing a picture, guessing and checking, acting it out, making a table, working backward, and using manipulative are problem-solving strategies set forth.

Problem: A problem, quantitative or otherwise, is a situation that requires resolution for which the individual sees no apparent path to the solution. It is a situation that requires analysis and synthesis of previously learned knowledge to resolve (Polya, 1962; Krulik & Rudnick, 1989).

Problem Solving: Problem solving is a process; the means by which an individual uses previously acquired knowledge, skills, and understanding to satisfy the demands of an unfamiliar situation. The designation of "problem" implies that the individual is being confronted by a situation he or she does not recognize. A situation cannot be considered a problem once it has been modeled or can be solved by a simple application of a recently learned algorithm (Krulik & Rudnick, 1989)

Constructivism: Constructivism is an individual framework that implies that knowledge is the result of a learner's activity rather than the passive reception of knowledge. The results of a learner's cognitive efforts have the purpose of helping him or her to cope in the world of his or her experience (Freiberg, Cornell, &Lorentz, 2001).

Heuristics: Heuristics are a set of general questions and prompts used during each state of the problem-solving process, applicable to all classes of problems .The four steps of the problem-solving process, as suggested by George Polya,are:(a) understand the problem,(b) devise a plan, (c) carry out the plan, and (d) look back at the problem, the answer, and what you have done to get there(Van de Walle,2004; Krulik &Rudnik,1989).

CHAPTER TWO

REVIEW OF THE LITERATURE

The determination of how to present curriculum for student understanding is complex and has many components. Teachers may draw on a variety of sources as they make decisions regarding classroom instruction. Effective teachers bring several types of knowledge to the classroom: (a) content knowledge of the topic to be presented, (b) curricular knowledge of instructional materials available to them, and, (c) pedagogical knowledge of how to represent ideas to learners so that they will comprehend. The combination of characteristics listed above leads teachers to make decisions about how and what they are to teach (Lesh, 2002). Researchers (Smith, 2001; Jonassen, 2000a; Loucks-Horsley, Hewson, Love, & Stiles 1998; Shavelson et aI., 1989) state that a model for teaching mathematical problem solving and understanding the process of teaching mathematical problem solving should include teachers' pedagogical knowledge, subject- area knowledge, substantive classroom explanation, classroom routines, and overt behavior.

Grouws and Good (1988) suggested that teacher practices are a powerful factor in increasing student performance. They commented that a careful study of teacher practices has the potential for making a contribution to the understanding of how student problem-solving ability may be improved in classroom settings. Other researchers (Hershkowicz et. al.2002) concurred that the role of the teacher in a problem-solving classroom is critical. Their study addressed the issue of teacher practices in the area of mathematical problem solving. Participating teachers in this study were observed to determine to what extent they practice mathematical problem-solving techniques in the classroom and if they selected appropriate pedagogical approaches. In order to teach students to become better problem solvers, it is necessary to determine the characteristics of good environments.

After extensive consultation with mathematicians, mathematics teachers and researcher analysis, the 2000 NCTM guidelines suggest the use of a problem solving approach to teaching mathematics across all content areas, and a constructivist approach in the mathematics classroom. In constructivist-oriented classrooms teachers become facilitators of learning, and students take on an active role in building their own mathematical understanding (NCTM, 2000). A constructivist approach in instructional design has been linked to successful problem solving (Jonassen, 2000a).

A. Constructivist Classroom Environments Support Mathematical Problem-solving

Research concerning constructivist environments in the mathematics classroom suggests that when teachers adopt a constructivist approach, learning becomes a problem-solving process (Ernest, 2002; Caprano, 2001; Cobb, et.al.1991).

Furthermore, they state that mathematics should be taught through problem solving. A constructivist approach to learning enables students to construct solutions that are acceptable in their current way of understanding and to talk about mathematics with each other. Grouws and Schultz (1996) concur, citing several examples of constructivist- oriented teacher professional development programs that demonstrated when teachers adopt the constructivist model for teaching, relinquishing strong classroom control, classroom problem solving similar to the Polya model emerges. Freiberg, et.al., (2000) demonstrated that the constructivist approach as recommended by the NCTM supported the development of the problem-solving process.

Chapman (1997) described teachers as facilitators of the learning of problem- solving skills and stated that teaching problem solving requires the coordination of teacher knowledge in both content area and pedagogy. The Chapman study focused on three teachers and their ways of teaching mathematical problem solving, using classroom observations and teacher interviews. Chapman found that teachers who approached the teaching of problem solving as a "community" activity of collaborative learning were successful in enabling students to participate successfully in problem-solving activities.

Clayton (1990) offered guidelines for effective teaching of mathematical problem solving. He stated that teachers need to facilitate learning, not dispense knowledge.

Clayton cited a study conducted by Peterson, et.al. (1983) in which the classroom practices of two groups of teachers were compared, using student achievement outcomes which evaluate the work of each group as the measure. One group of teachers participated in a problem-solving in-service class; the other did not. They found that teachers in the problem-solving group posed questions more frequently, expected students to use multiple representations in their work and started classes with story problems. The non-problem-solving teachers focused on computation and number fact. They also suggested that when teachers knew how to teach problem solving, they were able to and did change teaching strategies, resulting in better student skills.

The studies cited above suggest that constructivist-oriented classrooms provide an effective environment for learning mathematics through mathematical problem solving; and, both the 1989 and 2000 NCTM guidelines suggest that problem solving should cut across all content areas of mathematics. However, a clear definition of constructivism is not given in the NCTM guidelines; the guidelines merely suggest some teacher practices and classroom attributes that facilitate a constructivist environment. According to some researchers (Ernest, 1999; Noddings, 1990), constructivism does not entail a theory of teaching. A universally accepted definition of constructivism has not been determined, having nearly as many interpretations as practitioners and researchers. Derry (1996) suggests that there is no consensus on a definition due to the ethnocentric nature of constructivism. Furthermore, Ernest (1999) states that the problem of definition lies within the controversy over how mathematical knowledge is acquired. Is it entirely within the realm of the individual making sense out of his or her world, or is it socially dependent? The social constructivist position is that mathematical knowledge is a social construction that can be acquired through social interaction and is necessarily linked to language and culture. Ernest describes von Glasersfeld's radical constructivism as inherently centered on the individual construction of knowledge, as the individual makes sense out of his or her world. Ernest states that these two view points have implications in the way learning is conceptualized and the diversity of perspectives creates difficulty in establishing an operational definition. Freiberg, et, al. (2001) define constructivism as an educational framework that implies that knowledge is the result of a learner's activity rather than the passive reception of knowledge; that is the results of our cognitive efforts have the purpose of helping us to cope in the world of our experience. This is the operational definition used in this study.

The environment of a classroom is highly complex, and in order to effectively analyze a constructivist-oriented classroom, a classroom that is essentially activity oriented, it was necessary to select a framework that provides a way of capturing the nature of the activity, the object of the activity, the Participants in the activity, and the setting in which it occurs. Activity theory was selected as the mechanism for the investigation because it provided a tool to guide and direct analysis for the socially mediated learning model suggested by constructivism, the educational philosophy underlying the program under consideration.

Jonassen and Rohrer-Murphey (1999) stated that activity theory provides a powerful framework for designing constructivist learning environments and that activity theory is well suited to analyzing and understanding constructivist learning environments. Activity cannot be understood or analyzed out of context, and one must understand how the activity fits into the community. When analyzing an instructional setting, one must understand the goals, intentions, and what objects or products arise out of the activity. Therefore, it is necessary to clearly define the students, community in which they are participants, the rules governing the community, the activity, and the object of the activity. Activity theory provides a lens through which to view activity, the hallmark of a constructivist classroom (Jonassen, 2000b).

B. Activity Theory

Activity theory originated and developed in the Soviet Union during the 1920s with the work of W.L. Rubinshtein which stated that activity is not merely external behavior, but linked to consciousness. Conscious learning comes from activity. Vygotsky's work in the area of socially mediated learning influenced the development of the theory, and Vygotskyr's student, Leonfev, created an integrated framework for activity theory (Hung & Chen, 2000). Due to the political relations of the Soviet Union and the West, activity theory was not known in the West until much later in the century.

Hung and Chen (2000) describe a group of people working together on a project as a unit engaged in an activity, with its own objectives to be accomplished in order to produce an outcome. Group members function as a community of learners, working under a set of rules, using a division of labor and meditated by use of tools.

In this study, the teachers are the subjects, the tools are the mathematical problem solving skills and pedagogy that they have acquired through a professional development program and the outcome is the mathematics lesson. Division of labor can be viewed as the assignment of teachers to different schools and different grade levels. The community under consideration is the community of program participants from the partnering school district. The object under study is how and to what extent teachers from the grant program use the problem-solving content and pedagogical skills they have acquired in this professional development program. Kuutti (1996) also includes rules as part of the activity theory model.

For this program the "rules" are the criteria set for participating in the professional development program

Kuutii (1996) defines activity as the fundamental kind of context within which human actions take meaning. An activity has the following characteristics:

(a) An activity has a motive, a reason for the activity to take place. In this study it was a problem-solving lesson plan devised by a teacher.

(b) The activity is a collective phenomenon, as a group activity in a classroom. In this study, the teacher was engaged in presenting a lesson suited to the student's grade level and curriculum requirements.

(c) The activity must have a participant or group of participants who understand the motive for the activity. In the case of this study, the teacher filled the role of the participant who understood the motive. The teacher would ideally select an appropriate mathematical problem connected to the skills being developed.

(d) The activity is a historically developing phenomenon. The participant has to have enough emersion with the object to be able to act upon it or use it. Teachers must have a clear understanding of the problem solving them in order to enable their students to achieve an understanding of it.

(e) The activity is realized through conscious and purposeful actions of the participants. In the present study, the teacher actions were those under consideration.

As the result of a professional development program, the teachers in this study had developed their own personal knowledge for mathematical problem solving and the tools of pedagogical content knowledge about mathematical problem solving for their own classrooms. Teachers do not develop pedagogical approaches on their own. Research has shown, that without intervention, teachers will instruct their students similarly to the way they themselves were taught (Loucks-Horsley et al, 1998).Professional development can be an effective way to change teacher practices_and improve classroom learning environments.

C. The Attributes of Effective Professional Development

House (1994) states that educational change is not usually successful if it comes from outside the community of schools and those teachers are the key if change is to be realized. The way that teachers can be reached is through professional development. Effective professional development program address both content area and pedagogy, as well as model the desired teaching style.

Thompson (1992) posits that teachers tend to teach in the same way they themselves were taught. Smith (2001) and Loucks-Horsley et al. (1998) concur, and iterates that teachers need professional development because it is difficult to teach in ways in which one has not learned and suggest professional development programs need to model how teachers should be teaching. Other researchers agree, stating that teachers need to experience the desired mode of instruction as learners in order to teach in that manner of instruction (Connell, et, al.1994). Smith (2001) contends that teacher training this is a necessary component for the recommendations of the NCTM to be successfully implemented.

Acquarelli & Mumme (1996) also believe it is critical that the pedagogy of professional development match the pedagogy expected in the classroom. They state that professional development must be linked to classroom practices. If teachers are not given a practical way to apply the techniques and ideas of a professional development program in their classrooms; then techniques and ideas will not be used.

Loucks-Horsley et a1. (1998) stress on the importance of specific, content area professional development. They stated that pedagogical content knowledge is very important in mathematics teaching, in order to understand the different developmental levels of students' abilities and bring that understanding to their classroom implementation of grade level appropriate material.

Blume, et, al.(1998) stressed that professional development courses need to provide teachers with opportunities to be exposed to worthwhile mathematical ideas, to analyze mathematical ideas, to discuss common misunderstandings of ideas in their own and student's work, and discuss implementation of these ideas in their own classrooms. It is through professional development of this type that NCTM guidelines can be implemented.

The NCTM standards of 1989 and 2000 suggested a change in classroom organization in which students would no longer be passive recipients of knowledge and teachers would become facilitators of learning. Zollman and Mason (1992) found that familiarity with the NCTM standards did not imply that teachers agreed with or followed them. They found that teachers' classroom practices can be changed with proper knowledge and sufficient experiences. They compared two groups of teachers, those trained in the NCTM standards, and those not trained in the standards. After teachers received training, there was an improvement in orientation towards the NCTM's goals compared to those not trained in the standards.

Marks (1987) discuss a case study of a single teacher. He defined problem solving as a process that applies across the entire discipline of mathematics. Marks states that content knowledge of the subject, pedagogical skills, and knowledge of problem solving, impact teaching. He suggests that teacher professional development programs would be more effective if they were to concentrate on ways of thinking relative to the subject matter rather than general pedagogic techniques, a view supported by Loucks-Horsley et al. (1998). He also states that if teachers are to be successful models and facilitators of problem solving, they need professional development programs to provide support for the teaching of problem solving.

Raines and Guyton (2001) states that professional development must give teachers access to knowledge and understanding in ways that enable them to take possession of that knowledge and be able to adapt it to their own particular classroom environments. They point out that if teachers are to acquire new ways of looking at things, new personal learning strategies, and change in their knowledge, philosophy and theory, they must see a connection to classroom practice, and be able to negotiate this in a supportive community. Smith (2000) and Loucks-Horsley et al. (1998) agree, stressing the importance of on-going support of teachers through professional development if true changes are to be achieved. In addition, Connell et al. (1994) states that for a professional development program to be effective, sufficient time must be allowed for conceptual understanding and be thoroughly integrated into relevant classroom routines.

Simon and Schifter (1991) conducted a study using a four-stage intervention with teachers. Teachers participated in an intensive summer course to assist them in implementing a constructivist classroom approach in their own mathematics classroom decision-making. Through interviews and journal analyses with participants in the program, they found that teachers as facilitators of instruction were the creators of problem-solving situations. Simon and Schifter concluded that teachers must be encouraged to examine the nature of mathematics and the process of learning mathematics as a basis for deciding how to teach mathematics. In trying to develop new pedagogical approaches to teaching mathematics, the teachers themselves need to experience the targeted pedagogical approach. Furthermore, teachers must be challenged at their level of mathematical understanding and problem-solving ability.

Garet, et, al.(2001), conducted on a study using 1027 mathematics and science teachers, found three cores attributes of effective professional development: a focus on content knowledge, opportunities for active learning and the coherence with other learning activities to have a positive influence for changing teachers' classroom practices.

Additionally, they found that the collective participation of teachers from the same school, grade or subject to have an impact, as well.

In 1992, Hembree published a meta-analysis of 487 studies, covering the years 1920-1980, concerning experiments and relational studies in mathematical problem-solving. He concluded that there was a positive impact on student problem-solving success with teachers trained in the heuristic model of George Polya. The heuristic approach seemed "mildly" better than other approaches, especially at the middle school level. Of these 487 studies, only ten had teachers as the focus of the study. A survey of literature has shown that there have been few studies relating to mathematical problem solving since that time. Most studies of mathematical problem solving focus on student achievement rather than teacher implementation of problem-solving strategies. To more completely understand the problem-solving process in the mathematics classroom, more attention needs be focused on teacher practices.

Bums and Lash (1988) conducted a survey of nine seventh-grade teachers concerning their knowledge and planning of problem-solving instruction and how the teachers' conceptions about mathematics influenced the way they planned instruction on problem solving. The interviews revealed ambiguity about the definition of problem-solving. Since problem-solving strategies are more difficult to specify, the teaching of problem analysis directly was said to be difficult. The interviews revealed that teachers had limited pedagogical knowledge of how to teach problem solving. Modeling of problems and student practice of similar problems was the standard procedure. Bums and Lash showed content knowledge, curriculum knowledge, and pedagogical knowledge, as well as teaching techniques, all have an impact on lesson enactment.

Further, Thompson (1989) conducted a study to document the changes in the conceptions of mathematical problem solving of 16 elementary school teachers over a three week summer course on problem solving and after a year of teaching problem solving in their classrooms. He found that their perception of their own competence as problem solvers and their ability to teach problem solving influenced their performance and instructional actions in the classroom .Thompson reported that as a result of their participation in the professional development program, teachers were more confident in teaching problem solving and more knowledgeable of ways in which to help their students learn to do mathematical problem solving.

Many of the studies already discussed relied on teacher interviews and surveys, and found that while many teachers are aware of the NCTM recommendations for teaching mathematics, not all teachers put the recommendations into practice. Studies concerned with the implementation of the reform movement guidelines have found a dichotomy between reported activities and observed activities. Zambo (1994) surveyed 94 seventh and eighth grade teachers, asking questions concerning the current nature of mathematical problem solving instruction, and to what extent their reported classroom practices in problem-solving instruction reflect the NCTM recommendations. Questionnaires sought to determine the teachers' frequency of use of instructional strategies for problem solving and the usefulness of specific strategies for problem solving. Zambo(1994) also investigated time spent weekly on problem solving, teacher demographic data, teachers' self-assessment of their own problem-solving abilities and their students' problem-solving abilities. Zambo interviewed teachers identified as master teachers and observed them three times throughout the study. He found that most teachers agreed with the NCTM guidelines, and that even if teachers had not fully implemented the recommendations, they were aware of them. Only one of the three master teachers interviewed saw problem solving as a thread running through the mathematics curriculum to be used on a daily basis and did not view problem solving as limited to textbook word problems.

Bay (2000) discussed the increased amount of problem-solving teaching as a result of over two decades of emphasis on problem solving by the NCTM. Bay pointed out that the NCTM recommendations appear to be impacting teacher practices. Bay's study also noted that the emphasis on problem solving was especially effective with low and middle abilities groups and that teaching problem solving positively impacts student achievement in problem-solving objectives and in skill and concept development.

Bay discussed three ways in which problem solving is interpreted in the classroom: Teaching for problem solving, teaching about problem solving and teaching via problem solving. She identified teaching for problem solving as teaching a skill that will later be applied to problem-solving situations. Teaching for problem solving, results in a direct instruction, lecture style approach. Teaching about problem solving includes teaching Polya's heuristic model, and teaching via problem solving is teaching mathematics in a problem-solving context. A teacher teaching via problem solving would be facilitating student explorations. Teaching for problem solving showed no significant gains in computation, application or problem solving, but there was significant improvement in all mathematical domains when the teacher taught via problem solving.

She also noted that teacher's interpretations of how to teach problem-solving and time devoted to problem solving varied, even when the teachers believed they have aligned their classroom practices with the NCTM recommendations. Coben and Ball (1990) concurred, finding that teachers who thought they were implementing the new standards were not, in fact, doing it very well. Through several case studies of reforms in California studies, they determined that teachers adapted the guideline's suggestions to their own style of teaching, as opposed to truly modifying the classroom environment. Perhaps a lack of consensus for a definition of problem solving and how to teach it has caused mixed results.

The studies cited above support the idea that professional development impacts teacher decision making in the classroom. They also demonstrated that teacher practices can be changed through experience, reflective thought about classroom practices, professional development that provides direct links for classroom application, and supportive follow-up of in-service training .The studies also pointed out that teachers can perceive that they are implementing the NCTM guidelines, whereas in reality they are not or be aware of NCTM standards and not implement them (Bay, 2000; Zambo, 1994; Cohen and Ball, 1990).

The present study is designed to investigate how a professional development program teaching problem- solving skills to teachers effects the implementation of problem-solving strategies in the classroom. Some of the studies cited above concentrated on teacher practice in general, some concentrated on constructivist classroom practices as recommended by the NCTM guidelines. Many or the studies were qualitative case studies based on as few as two teachers or teacher survey.

D. Summary

As the literature review revealed, few, if any studies have included actual observations of teachers in classrooms as they taught mathematical problem solving. Most studies concerning teachers used case studies of a single teacher or self-report surveys of teachers' beliefs about mathematical problem solving or levels of awareness regarding the NCTM standards. Most problem-solving studies have involved student achievement, with little attention paid to the role of the teacher and activity in the classroom. As Zambo (1994) and Cohen and Ball(1990) have observed, teacher perception of their use of problem- solving activities may not correlate with the NCTM recommendations in this area. The NCTM suggests what teacher practices should be, and many teachers believe hey are following NCTM guidelines, only actual observation can determine what really happens in the classroom .This study tries to determine how teachers actually used the skills and techniques learned in professional development classes. It differed from the studies above in that these teachers have experienced both content area training and pedagogical training in the area of mathematical problem solving. The study yielded both qualitative data and quantitative data to enrich and bring further understanding to the investigation.

Based on the above research findings, the following hypotheses have been derived and tested in the present study, they are:

H1 Teachers with training in mathematics problem solving through a professional development program will help their students achieve more in problem solving than those teachers who have not attended the professional development program.

H2 Teachers with training in mathematics problem solving through a professional development program will help their students more in understanding certain competencies in mathematics than those teachers who have not attended the professional development program.

H3 Teachers with training in mathematics problem solving through a professional development program will be better perceived by their students than those teachers who have not attended the professional development program.

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CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

Research has indicated that it is possible to alter classroom practices through effective professional development, especially those that offer continuing support, as opposed to one time events (Taplin & Chen, 2001; Smith 2001; Coucks-Horsley, et al., 1998; Simon & Schilfter, 1991). Research also demonstrates that using the desired teaching technique throughout the professional development training facilitates the teachers' use of the technique in their own classrooms (Taplin & Chen, 2001; Smith, 2001). This study considers the effectiveness of a teacher professional development program in which middle school mathematics teachers have been trained in problem-solving techniques to use as they solve problems, as well as how to teach students problem-solving strategies. This professional development program consisted of two level classes. In the first class, teachers learned mathematical problem-solving techniques, and in the second course they practiced teaching problem –solving activities in each of the mathematics content strands using a constructivist approach.

A. Purpose

The purpose of this study is to assess the differences in the teaching of problem solving strategies and the use of problem-solving activities in the classroom between teachers who are trained in problem-solving techniques and teachers who are not trained in any kind of professional development programs to enhance techniques in problem solving strategies. This analysis of observable teacher practices helped to determine if teacher participants used the teaching techniques they learned, and to what extent teachers actually implemented problem-solving practices in their classroom. Should our findings concur with other findings, then administrators will see the need to either provide mathematics teachers with either in-service or workshops training in problem solving techniques to better assist their students in this area.

B. The Professional Development Program

The trained group of teachers in this study participated in a mathematical problem-solving professional development program during the summer of 2003, and throughout the following academic year, 2003-2004.The summer class met for 12 hours per week for 4 weeks, and the class during the academic year met for a 4-hour session one afternoon per month for 6 months.

The summer development program class used *Problem-Solving Strategies: Crossing the River with Dogs and Other Mathematical Adventures* by Herr and Johnson (1999) as its textbook. The textbook developed each chapter to a particular problem-solving strategy, and the problems ranged from easy to difficult. Mathematical problem solving was taught in a constructivist manner, with small group work and teacher presentations of multiple solutions to problems. Teachers were encouraged to use the problem-solving model of George Polya .This model requires that the student be able to understand the problem, form a plan for solving the problem, implement the plan and reflect on the reasonableness of the solution(Polya,1962) and as mentioned earlier ,this four step model first suggested by George Polya has become the model used by mathematics educators since 1945(Van de Walle,2004).Teachers were encouraged ,as well, to become familiar with problem-solving strategies, and develop appropriate problem-solving heuristics. After teachers worked together or individually, a mathematics lesson was presented by the professor when needed, to highlight and tie together some of the mathematics concepts involved in problem-solving. Most of the teachers in the class were new to this method of teaching problem solving and were challenged by the problems.

As a follow-up to the summer program, the teachers were then enrolled in an in-service training program, taught by the same professor, whose purpose was to train the teachers to teach mathematical problem solving to their students. The classes met one 4-hour afternoon per month for 6 months. Every month a group of teachers would present three middle school problem-solving activities related to a mathematical strand. Throughout the classes, problem-solving in each of the mathematics strands as established by the NCTM (2000) were addressed: number and operations, patterns and algebra, data analysis and probability.

C. Methodology

The study is conducted on two groups of students: the first group consisted of 50 participants whose teachers are provided with on-going professional training in the area of problem solving where they participate in four in-service training workshops held throughout the school year. The other group consisted of another 50 participants whose teachers are not provided with any kind of professional training in this area. Both groups were provided the same test to compare their problem-solving acquisition.

The test group and the control group are chosen from schools located in the Beirut area and participants (subjects) are in grades 8 and 9 aged between 12 and 15 years. The students of grade 8 from the test group will be compared to students of grade 8 from the control group and students of grade 9 from the test group will be compared to students of grade 9 from the control group. All of the students in these grades were asked to complete: a test drawn from their curriculum, and completed a self-administered questionnaire on a four point scale.

From the literature findings, the grades chosen are most suitable for testing problem-solving skills because problem-solving is already a part of the curriculum and the critical thinking of the students should be more advanced due to the training received in cycles one and two. The English proficiency in these grades is also more advanced and is needed for understanding problem-solving questions that are presented in English.

D. Procedure

A letter was delivered to each school principal explaining the nature of the study (see Appendix A) and requesting permission to conduct the research. A meeting was held with the Head of the Department to agree on the time and place of the exam. The exam was given in the presence of the researcher. Subsequent to the exam, the researcher met with the students to explain the nature of the questionnaire which was completed to evaluate teachers' assistance and explanation of problem solving.

E. Research Instrument

The experiment constitutes two parts. The first part is the problem solving assessment (see appendix B) .For grade eight, the test was composed of seven problems designed to test the five different competencies: expressing ideas in a mathematical language, shifting from one mode of representation to another, choosing the needed operation to solve a problem, using various types of reasoning to solve a problem, and validating and interpreting results. Not all of the seven problems were of the same level of difficulty or tested equally for the five different competencies. Each question was put on a difficulty level of easy (problems1 and 2), medium (problems 3, 4, and 5), or difficult (problems 6 and 7).For grade nine, the test was composed of ten problems designed to test the five different competencies: expressing ideas in a mathematical language, shifting from one mode of representation to another, choosing the needed operation to solve a problem, using various types of reasoning to solve a problem, and validating and interpreting results. Again, not all the ten problems were of the same level of difficulty (problems 5, 6, and 7 were difficult) or tested equally the five competencies (problems 1 and 2). The second part of the experiment was a self-administered Questionnaire (see Appendix C) with a four point scale. Each student in the test group and in the control group was asked to fill a self-administered questionnaire aimed at evaluating student's own performance and their teacher's role in achieving that performance.

A pilot study was conducted with a group of students from the same grades and ages as the test and control groups but from a third private school in the Beirut Area. The purpose of the pilot study was to make sure that all problems on the test were understood and suitable to the age and class level for our students in Lebanon.

F. Analysis

The problem solving assessment and the self-administered questionnaire was analyzed using SPSS software. The problem solving assessment was compared to the total score of the test group and the control group participants and also compared the results of each question (competency) separately. The results of both group was compared by calculating the mean scores of the test group and the control group. ANOVA was used to identify significant differences between the means scores. Analysis was achieved on a 95% confidence level. Questions in the self-administered questionnaire were analyzed by calculating the mean scores of the questions with the Standard Deviation. Comparison between the test and the control groups was accomplished using ANOVA at a 95% confidence level.

G. Limitations

Teachers participating in this study, both comparison and treatment were consistently engaged with their students in an instructional capacity. Teachers made great efforts to communicate mathematics to their students and had carefully planned lessons. Their concerns about student achievement on high stakes tests and a demanding curriculum may not allow much time for students' explorations and may cut into the effort to implement problem-solving activities, even though literature suggests that a problem-solving approach leads to better understanding of mathematics and can translate into more success with basic skills (Bay, 2000).

Classroom management issues may also dictate and control the frequency of true problem-solving lessons. Ideal problem-solving classrooms are not quiet places, but rooms busy with students discussing mathematical ideas. Some teachers and administrators may not be comfortable straying from orderly rows of quiet students working on individual assignments to what is suggested in the literature.

Other limitations that should be taken into considerations are:

a. Time limitations

Student performance in this study is tested through the class average on one exam. This may not have been a sufficient measure in evaluating the students' performance in math. The teachers' ability, motivation, and work situation could have influential effect on the students' performance which may not necessarily show in our test.

b. Questioning limitations

Another limitation that could be taken into consideration is the fear of the students in solving the test or in completing the Questionnaire. As to the test, the students might feel that they are under certain pressures (place of the test, People that they are not accustomed to seeing running the test) which might affect their performance. As to the Questionnaire, the students might fear expressing their honest ideas even though they will be told about the confidentiality of the questionnaire. This might affect their objectivity in answering.

c. Cultural limitations

Any researcher collecting data n Lebanon might face a cultural limitation. The majority of students might not be accustomed to or acquainted with this type of questionnaire. Others may have not been involved in research participation or studies and may be unfamiliar with answering questions of this sort.

d. General limitations

The results of this study cannot be generalized to the whole of Lebanon. The results are limited to English speaking private schools in the proper Beirut area.

CHAPTER FOUR

RESULTS

Much research in the areas of mathematical problem solving have focused on student achievement, yet there is a lack of research regarding teacher practices in mathematical problem solving .The purpose of this study was to determine if a professional development program teaching mathematical problem-solving skills affected participating teachers' classroom practices .Did these teachers, in fact ,provide problem –solving opportunities more frequently than teachers who had not participated in the professional development program? As the literature has pointed, a constructivist approach to teaching is conducive to teaching through problem solving (Jonassen & Rohrer-Murphy, 1999; Cobb, Wood& Yackel, 1991).Were there differences between the two groups in the use of the problem – solving model? Was the quality of teachers' lessons different?

A. Treatment and Control Groups

To conduct this study, two groups of teachers were compared based on the achievement and perception of their corresponding students. These two groups were a treatment and a control group. The treatment group consisted of 2 teachers who received a professional development program in training teachers in enhancing mathematical problem-solving skills. The control group consisted of 2 teachers who did not receive any training program in the mathematical problem solving field.

The teachers of the two groups were matched as closely as possible with respect to level of experience and type of academic degrees in mathematics. In addition, the teachers of the 2 groups were selected from similar standard schools and taught grades 8 & 9.

B. Results and Data Analysis

Hypothesis one: Teachers with training in mathematics problem solving through a professional development program will help their students achieve more in problem solving than those teachers who have not attended the professional development program.

An independent t-test was run to check for the difference in the grades between students whose teachers had participated in the professional development program and students whose teachers did not participate in the program or any other program of similar nature.

Table 4.1: Statistical data of the whole group

Group Statistics

Group		N	Mean	Std. Deviation	Std. Error Mean
Grade	Teacher did not receive training	50	8.960	3.524	0.498
	Teacher received training	50	10.660	3.293	0.466

Table 4.1.1: Results of independent t-test for students' grades (teachers with training vs. teachers without training).

Independent Samples Test

		t-test for Equality of Means			
		t	d f	Sig. (2-tailed)	Mean Difference
Grade	Equal variances assumed	-2.493	98	0.014	-1.700

We found that there exists significant evidence to state that the average grades on the math test for students with teachers who took training sessions is higher than that of students who took it with teachers who did not attend training sessions; with an average of 1.7 grade points higher for students who took their class with teachers who received training (p-value=0.014< a =0.05).

Furthermore, an independent t-test was run to compare students of the treatment group in grade 8 with students of the control group of the same class. Also, an independent t-test was run to compare students of the treatment group in grade 9 with students of the control group of the same class. The following results were revealed:

With a 95% confidence level, one can conclude that there is a significant difference between the scores of students of grade 8 who were taught by teachers who received training and those of the same grade who were taught by teachers without training. (p-value=0.011< a = 0.05) whereby this difference is of an average of 1.8 grades higher for students whose teachers participated in the professional development program.

Table 4.2: Statistical data of the whole group

Group Statistics

Group (grade 8)		N	Mean	Std. Deviation	Std. Error Mean
Grade	Teacher did not receive training	50	8.960	3.524	0.498
	Teacher received training	50	10.660	3.293	0.466

Table 4.2.1: Results of independent t-test for students' grades (teachers with training vs. teachers without training).

Independent Samples Test

		t-test for Equality of Means			
		t	d f	Sig. (2-tailed)	Mean Difference
Grade	Equal variances assumed	-2.493	98	0.014	-1.700

With respect to grade 9, an average difference of 1.6 grades higher for students whose teachers had training in the professional development program did not prove to be significant enough to conclude that grade 9 students whose teachers had training had higher achievement than grade 9 students whose teachers did not participate in a professional development program. (p-value =0.132 >a =0.05)

Table 4.3: Statistical data of the whole group

Group Statistics

Group (grade 9)		N	Mean	Std. Deviation	Std. Error Mean
Grade	Teacher did not receive training	50	8.960	3.524	0.498
	Teacher received training	50	10.660	3.293	0.466

Table 4.3.1: Results of independent t-test for students' grades (teachers with training vs. teachers without training).

Independent Samples Test

	t-test for Equality of Means			
	t	d f	Sig. (2-tailed)	Mean Difference
Grade Equal variances assumed	-2.493	98	0.014	-1.700

Hypothesis Two: Teachers with training in mathematics problem solving through a professional development program will help their students more in understanding certain competencies in mathematics than those teachers who have not attended the professional development program.

Since grades 9 & 8 had different sets of problems testing the different competencies; we compared the treatment group and control group per grade using The Pearson Chi- Square test through cross tabulation. The following tables will summarize the p-value or the significance of the x^2-test when comparing teachers who participated in a professional training program and those who did not participate in the program for each competency across each question.

Grade Nine:

Table 4.4: Significance of x^2 - test for competencies of grade nine

Questions/competencies	C1,expressing ideas in mathematical language	C2,shifting form mode of rep. to another	C3 using types of reasoning to solve a problem	C4,choose the needed operation to solve a problem	C5,validate and interpret a result
1	No test done	0.307	0.046*	0.050(1)	0.181
2	0.564	0.018*	0.237	0.777	0.370
3	0.766	0.799	0.545	0.317	0.534
4	0.564	0.171	0.105	0.072	0.295
5	0.161	0.007*	0.045*	0.070	0.673
6	0.069	0.39	0.004*	0.001*	0.339
7	0.000*	0.000*	0.001*	0.003*	0.032*
8	0.001*	0.258	0.248	0.382	0.529
9	0.077	0.654	0.237	0.239	0.733
10	0.087	0.077	0.355	0.355	0.733

- Problem one : competency 3 (use various types of reasoning) ended up being significantly different between the two groups whereby more students whose teachers had training in problem solving showed more use of this competency than students whose teachers did not have training in the same field.(p-value=0.046 < a =0.05).
- Problem two: competency 2 (shifting from one mode of representation to another) ended up being significantly different between the students whose teachers had training and students whose teachers did not have training (p-value=0.018< a =0.05).
- Problems three and four showed no differences among all the competencies between the two groups.
- Problem five: competencies 2 & 3 (shifting from one mode of representation to another & use various types of reasoning respectively) were significantly different where students

whose teachers had training showed more use of the two competencies than students whose teachers did not have such training (p-value=0.007&0.045 respectively<a = 0.05).

- Problem six: showed significant differences among competencies 3(uses various types of reasoning to solve problems) and 4(chooses the needed operation) where students whose teachers had training revealed more use of these two competencies than those whose teachers did not have training (p-value= 0.004 & 0.001 respectively< a =0.05).
- Problem seven : This problem showed a highly significant difference among all the five competencies(expresses ideas in mathematical language, shifts from one mode of representation to another, uses various types of reasoning to solve problems, chooses the needed operations, validates and interprets results) showing that students whose teachers participated in the professional development program showed much more use of the five competencies in solving problem seven as compared to students whose teachers did not participate in the program(p-values= 0.000, 0.000, 0.001, 0.003, 0.032 respectively<a= 0.05).
- Problem eight: high significant difference was proved for the first competency (expresses ideas in mathematical language) between the treatment group and the control group (p-value =0.001<a =0.05).
- Problems nine and ten: showed no significant differences among all the five competencies. (expresses ideas in mathematical language, shifts from one mode of representation to another, uses various types of reasoning to solve problems, chooses the needed operations, validates and interprets results).

Grade Eight:

Table 4.5: Significance of x^2 - test for competencies of grade eight

Questions/ competencies	C1,expressing ideas in mathematical language	C2,shifting form mode of rep. to another	C3 using types of reasoning to solve a problem	C4,choose the needed operation to solve a problem	C5,validate and interpret a result
Q1	Not tested	0.297	0.297	0.031*	1.000
Q2	0.149	0.018*	0.239	0.777	0.0370
Q3	1.000	0.637	0.870	0.021*	0.185
Q4	0.384	0.208	0.047*	0.015*	0.480
Q5	0.637	0.003*	0.010*	0.010*	0.225
Q6	0.123	0.002*	0.001*	0.000*	0.004*
Q7	0.012*	0.000*	0.005*	0.005*	0.0136

- Problem one: showed significant difference in competency four (chooses the needed operations) between the two groups whereby students whose teachers had training in problem solving showed more use of this competency than students whose teachers did not have training. (P-value= 0.013<a =0.05).
- Problem two: competency 2 (shifting from one mode of representation to another) ended up being significantly different between students whose teachers had training and students whose teachers did not have training (p-value=0.018< a =0.05).
- Problem three: high significant difference was proved for the fourth competency (chooses the needed operations) between the treatment group and the control group. (p- value = 0.021< a =0.05).
- Problem four: significant differences were shown among competencies 3(uses various types of reasoning to solve problems) and competency 4(chooses the needed operation) where students whose teachers had training revealed more use of these competencies than those whose teachers did not have training (p-value =0.047 & 0.015 respectively <a = 0.05).

- Problem five: This problem showed a highly significant difference among three competencies: one, two, and three(expresses ideas in mathematical language, shifts from one mode of representation to another, uses various types of reasoning to solve problems) showing that students whose teachers participated in the professional development program showed much more use of the mentioned competencies in problem solving as compared to students whose teachers did not participate in the program (p-values= 0.003, 0.010, 0.010 respectively <a=0.05).
- Problem six: this problem showed significant differences among competencies 2(shift from one mode of representation to another), 3(uses various types of reasoning to solve problems), and 4(chooses the needed operation) showing that students whose teachers participated in the professional development program used more these three competencies than students whose teachers did not have training (p-value= 0.002, 0.001, and0.000 respectively<a=0.05).
- Problem seven: high significant difference was proven for competencies 1(expresses ideas in mathematical language), 2(shifts from one mode of representation to another), 3(uses various types of reasoning), and 4(chooses the needed operation) between students whose teachers had training and students whose teachers did not have training (p-value=0.012, 0.000, 0.005, and 0.005 respectively <a =0.05).

Hypothesis Three: Teachers with training in mathematics problem solving through a professional development program will be better perceived by their students than those teachers who have not attended the professional development program.

Students who had teachers who participated in a professional development program in mathematical problem-solving showed high significant differences with p-values < 0.05

about the perception of their abilities and their teachers' abilities than students whose teachers did not participate in such a program as shown in the following table:

***Table 4.6*:** **One -Way ANOVA – The whole Group**

By Teacher Training For the Whole Group

		Sum of squares	df	Mean Square	F	Sig.
Are you satisfied with performing problem solving exam?	Between Groups Within Groups Total	29.690 30.020 69.710	1 98 99	29.690 0.306	129.568	0.000
Do you think the teacher's explanation of word problems help you solving this test?	Between Groups Within Groups Total	40.960 36.200 77.160	1 98 99	40.960 0.369	110.886	0.000
Do you spend enough time on problem solving in class?	Between Groups Within Groups Total	27.040 38.920 65.960	1 98 99	27.040 0.397	68.086	0.000
Were you familiar with similar kinds of problem solving before?	Between Groups Within Groups Total	51.840 38.160 90.000	1 98 99	51.840 0.389	133.132	0.000
Do you have difficulty in understanding the English language in the word problem?	Between Groups Within Groups Total	50.410 56.340 106.750	1 98 99	50.410 0.575	87.685	0.000
Does the test reflect your teacher's work?	Between Groups Within Groups Total	34.810 44.100 78.910	1 98 99	34.810 0.450	77.356	0.000
Do you find a relation between word problems and your daily life experience?	Between Groups Within Groups Total	56.250 62.740 118.990	1 98 99	56.250 0.640	87.863	0.000
Do you discuss the solution of a word problem in class	Between Groups Within Groups Total	36.000 27.000 63.000	1 98 99	36.000 0.276	130.667	0.000
Do you spend enough time on solving and discussing word problems in class?	Between Groups Within Groups Total	30.250 26.740 56.990	1 98 99	30.250 0.273	110.864	0.000
Are you able to create a word problem to a friend?	Between Groups Within Groups Total	92.160 42.800 134.960	1 98 99	92.160 0.437	211.021	0.000

***Table 4.7*:** **One -Way ANOVA – Grade Eight**

By Teacher Training For the Group Grade Eight

		Sum of squares	df	Mean Square	F	Sig.
Are you satisfied with performing problem solving exam?	Between Groups Within Groups Total	23.120 16.160 29.280	1 48 29	23.120 .337	68.673	.000
Do you think the teacher's explanation of word problems help you solving this test?	Between Groups Within Groups Total	19.220 21.360 40.580	1 48 49	19.220 .445	43.191	.000
Do you spend enough time on problem solving in class?	Between Groups Within Groups Total	12.500 23.520 36.020	1 48 49	12.500 .490	25.510	.000
Were you familiar with similar kinds of problem solving before?	Between Groups Within Groups Total	20.480 22.240 42.720	1 48 49	20.480 .463	44.201	.000
Do you have difficulty in understanding the English language in the word problem?	Between Groups Within Groups Total	23.120 27.360 50.480	1 48 49	23.120 .570	40.561	.000
Does the test reflect your teacher's work?	Between Groups Within Groups Total	20.480 25.440 45.920	1 48 49	20.480 .530	38.642	.000
Do you find a relation between word problems and your daily life experience?	Between Groups Within Groups Total	27.380 32.800 60.180	1 48 49	27.380 .683	40.068	.000
Do you discuss the solution of a word problem in class	Between Groups Within Groups Total	12.500 14.000 26.500	1 48 49	12.500 .292	42.857	.000
Do you spend enough time on solving and discussing word problems in class?	Between Groups Within Groups Total	15.680 12.320 28.000	1 48 49	15.680 .257	61.091	.000
Are you able to create a word problem to a friend?	Between Groups Within Groups Total	30.420 25.360 55.780	1 48 49	30.420 .528	57.577	.000

***Table 4.8*: One -Way ANOVA – Grade Nine**

By Teacher Training For the Group Grade Nine

		Sum of squares	df	Mean Square	F	Sig.
Are you satisfied with performing problem solving exam?	Between Groups	16.820	1	16.820	65.110	.000
	Within Groups	12.400	48	.258		
	Total	29.220	49			
Do you think the teacher's explanation of word problems help you solving this test?	Between Groups	21.780	1	21.780	70.638	.000
	Within Groups	14.800	48	.308		
	Total	36.580	49			
Do you spend enough time on problem solving in class?	Between Groups	14.580	1	14.580	54.675	.000
	Within Groups	12.800	48	.267		
	Total	27.380	49			
Were you familiar with similar kinds of problem solving before?	Between Groups	32.000	1	32.000	101.587	.000
	Within Groups	15.120	48	.315		
	Total	47.120	49			
Do you have difficulty in understanding the English language in the word problem?	Between Groups	27.380	1	27.380	45.633	.000
	Within Groups	28.800	48	.600		
	Total	56.180	49			
Does the test reflect your teacher's work?	Between Groups	14.580	1	14.580	38.035	.000
	Within Groups	18.400	48	.383		
	Total	32.980	49			
Do you find a relation between word problems and your daily life experience?	Between Groups	28.880	1	28.880	47.087	.000
	Within Groups	29.440	48	.613		
	Total	58.320	49			
Do you discuss the solution of a word problem in class	Between Groups	24.500	1	24.500	98.000	.000
	Within Groups	12.000	48	.250		
	Total	36.500	49			
Do you spend enough time on solving and discussing word problems in class?	Between Groups	14.580	1	14.580	48.600	.000
	Within Groups	14.400	48	.300		
	Total	28.980	49			
Are you able to create a word problem to a friend?	Between Groups	64.980	1	64.980	236.291	.000
	Within Groups	13.200	48	.275		
	Total	78.180	49			

CHAPTER FIVE

CONCLUSIONS, IMPLICATIONS AND SIGNIFICANCE

The goal of this study was to determine if a professional program designed to teach mathematical problem solving to teachers had a significant impact on teacher classroom practices. A treatment and control groups of teachers were considered to study the differences in the area of mathematical problem solving.

Four middle school teachers from two different schools in the Beirut area were selected for the study. The treatment group of two teachers had participated in the professional program while their matched-pair counterparts had not. The research hypotheses were:

1- Teachers with training in mathematics problem solving through a professional development program will help their students achieve more in problem solving than those teachers who have not attended the professional development program.
2- Teachers with training in mathematics problem solving through a professional development program will help their students more in understanding certain competencies in mathematics than those teachers who have not attended the professional development program.
3- Teachers with training in mathematics problem solving through a professional development program will be better perceived by their students than those teachers who have not attended the professional development program.

In regards to our findings, **Hypothesis One:** Teachers with training in mathematics problem solving through a professional development program will help their students achieve more in problem solving than those teachers who have not attended the professional development program, showed a significant relation between those teachers who had participated in the professional training program and the results of their students. The difference in average grades was 1.7 higher for these students than students whose teachers did not receive training (p-value=0.014).For grade 8,there was a significant difference between the treatment group and the control group where the results showed that students whose teachers received training got average grades higher by at least 0.423 than students whose teachers did not receive training while in grade nine the difference was not that significant because the curriculum itself in grade nine incorporates problem-solving and teachers have to be capable somehow to prepare their students in this area because of the government exams. But as mentioned earlier, the results between groups showed that teachers with training had better results with their students. Logically, this makes sense. Most teachers in Lebanon do not have enough training during their university years either in methods or in school experience. Further, most teachers have not either gone through a program where critical thinking was taught in school and this is why the new government curriculum stressed on this notion. This curriculum has only been in place for seven years and hence there is no evidence as yet to indicate whether or not it is working. This study revealed that teachers in the professional development program implemented the problem-solving to varying degrees. Burns (1988) and Lash (2000) noted that problem solving is interpreted by the teacher for use in the classroom and suggest that research in this area will continue to bring mixed results because teachers and researchers are not working with common understanding of what mathematical problem solving is.

Hypothesis two: Teachers with training in mathematics problem solving through a professional development program will help their students more in understanding certain competencies in mathematics than those teachers who have not attended the professional development program. The results of grade nine showed that the treatment group was more able to handle difficult problems than the control group. Problems five and six that were considered of medium level of difficulty showed significant differences in two competencies each. Problem five in competencies 2 & 3(p-values=0.007& 0.045 respectively) and problem six in competencies 3 & 4(p-values=0.004&0.001). Problem seven which was considered of high level of difficulty showed very significant differences between the two groups. The students whose teachers had training performed better in the five competencies (p-values=0.000, 0.000, 0.001, 0.003, 0.032). This shows that teachers who participated in the professional development program gave their students more opportunities to be more exposed to quality problems that spark their curiosity and enhance their learning. For grade eight, again the results showed that teachers with training were more able to prepare their students to handle problems of medium and high level of difficulty. This was clearly shown in problem four where the differences were significant in two competencies (3&4) having p-values of 0.047 &0.015 respectively and problem six where the differences were highly significant in competencies (2&3) having p-values=0.002 & 0.001. When the problems became more difficult, the differences were greater. In problem five, the significant differences were in competencies (1, 2, &3) with p-values=0.003, 0.010, 0.010 respectively and in problem seven the highly significant differences were in competencies (1, 2, 3, &4) having p-values=0.012, 0.000, 0.005, 0.005. The results of the treatment group and the control group showed that in-service training plays a great deal in preparing the students to become better problem solvers. This may be due to the fact that teachers who are provided with training are more apt in using various methods to meet student needs and know better what they are talking about more than teachers who have not received training

HYPOTHESIS THREE: Teachers with training in mathematics problem solving through a professional development program will be better perceived by their students than those teachers who have not attended the professional development program. The results were analyzed between groups and between classes.

Question five tried to explore the language difficulty in problem solving and the results showed that teachers in both groups have had difficulties regarding this issue where only 16% only said that they have no difficulty language wise and 25% said that they always have problems related to language. This should be taken into consideration and coordination meetings should be arranged between mathematics teachers and language teachers.

Table 5.1: FREQUENCY TABLE – Question Five

Do you have difficulty in understanding the English language in the word problem?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	never	16	16.0	16.0	16.0
	sometimes	38	38.0	38.0	54.0
	frequently	21	21.0	21.0	75.0
	always	25	25.0	25.0	100.0
	Total	100	100.0	100.0	

Question seven tried to link problem solving to daily life. Only 26% said that they always find a relation between problem solving and daily life. This indicates that the curriculum of problem-solving should incorporate problems based on a strong relation with daily life and that critical thinking has to be more focused on.

Table 5.2: FREQUENCY TABLE – Question Seven

Do you find a relation between word problems and your daily life experience?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	never	21	21.0	21.0	21.0
	sometimes	35	35.0	35.0	56.0
	frequently	18	18.0	18.0	74.0
	always	26	26.0	26.0	100.0
	Total	100	100.0	100.0	

Question ten tried to explore the possibilities of students in creating problems. The results showed that only 29% said that they are able to do so. This indicates that students are dealing with problem solving on a superficial level inside the classroom only and they are not profiting from this exercise as to be able to solve problems related to their daily lives. If students were able to make this relationship, only then will students show signs of critical thinking and acquire the abilities needed to perform better both in and outside of the classroom.

Table 5.3: FREQUENCY TABLE – Question Ten

Are you able to create a word problem to a friend?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	never	26	26.0	26.0	26.0
	sometimes	25	25.0	25.0	51.0
	frequently	20	20.0	20.0	71.0
	always	29	29.0	29.0	100.0
	Total	100	100.0	100.0	

A. The Attributes of Effective Professional Development.

Researchers suggested that in order to change teacher practices it is necessary to teach professional development programs in the desired teaching style (Loucks-Horsley et al., Blume et al., 1998; Raines & Guyton, 2001). The work of Smith (2001), Loucks-Horsley (1998), and Thompson (1992) stated that teachers will teach in the way they were taught, and will continue to do so without exposure to other teaching techniques. Research has also shown that professional development programs have impacted teacher decision making in the classroom, particularly if change is supported over time and application made practical (Connel, et al., 1994; Acquirelli & Mumme, 1996). The present study reveals that the teachers who participated in the professional development program organized their lessons to help their students to become better problem solvers. Changes in teacher practices are slow to be implemented and must be accomplished on personal a basis (Smith 2001; Loucks-Horsley, et al., 1998).Teachers that do not have first-hand opportunities for continuing professional development will not have the necessary information or resources to change their classroom practices. The literature suggests that on-going professional development support is necessary to keep the new ideas learned in professional development situations in use (Smith, 2001; Loucks-Horsley, et al., 1998). Teachers who participated in the professional development program had an awareness of the need for problem-solving activities to foster understanding of mathematics and higher level thinking. Administrators are responsible for providing development programs and should strive to find those programs that offer support throughout the year.

B. Implications for Further Research

This study would have been more effective if there had been more observations and if the observations were to have been made during a longer period of time throughout the school year. If the study were to be repeated, problem-solving lessons could be required for a certain period of time for both the treatment and comparison groups, and teachers could be interviewed to determine their understanding of what problem solving is.

English et al. (2002) suggest that more research needs to be conducted in the areas of teacher education and teacher development programs that can facilitate student access to powerful mathematical ideas. Furthermore, they state that assessing teachers' professional growth and instructional programs presents great challenges, and that the assessment instruments up until now have been poorly aligned views of the nature of mathematics, problem solving, learning, and teaching. Gains in student achievement are only one of many factors that should be considered, and given the variety of students teachers deal with and the strengths and weaknesses of the teachers themselves, information relying solely on student results is incomplete.

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APPENDIX A

SAMPLE OF THE LETTER ADDRESSED TO THE PRINCIPLES

Dear Principle

We would like to ask you to allow Mr. Elias Shoufani, a graduate student at Hagazian University, to conduct his thesis research at your school. The Title of his thesis is " **The Effects Of A Professional Development Program On The Implementation Of Mathematical Problem Solving In The Classroom"**. Please be advised that at no time will the name of the school be mentioned.

Thank you in advance for your cooperation and should you have any further questions regarding the student, please do not hesitate to contact me.

Sincerely,

Ahlam Klailat, Ph. D.

Chair, Social and Behavioral Department

APPENDIX B

SAMPLE OF THE PROBLEM SOLVING TESTS

Math Test Grade 8
Problem Solving

1—Nancy has a test score of 75 on her first test. What must she score in a second test to have an average of 83 on the two tests?

2—The sum of three times a number and 8 is -22. What is the number?

3 – Fred has already typed 13 pages of a 25-page report. If he can type two pages in an hour, how many hours will it take him to finish typing the report?

4 – The sum of two consecutive integers is 229. What are the integers?

5 – A board 40 cm long is cut into two pieces. One piece is 7 cm longer than twice the length of the other piece. Find the length of each piece.

6 – Find three consecutive even integers whose sum is 66 . (use x, x+2, and x + 4 to represent the three odd integers)

7 – The sum of the degree measures of the three angles of a triangle is 180. If the measures of the angles are consecutive even integers, what are the measures of the angles?

APPENDIX B

SELF ADMINISTERED QUESTIONNAIRE

Questionnaire

1 -- Are you satisfied with performing problem solving exams?
(1) Never Occurs
(2) Sometimes
(3) Frequently
(4) Always

2 – Do you think the teacher's explanation of word problems help you in solving this test?
(1) Never Occurs
(2) Sometimes
(3) Frequently
(4) Always

3 – Do you spend enough time on problem solving in class?
(1) Never Occurs
(2) Sometimes
(3) Frequently
(4) Always

4 – Were you familiar with similar kinds of problem solving before?
(1) Never Occurs
(2) Sometimes
(3) Frequently
(4) Always

5 – Do you have difficulty in understanding the English language in the word problem?
(1) Never Occurs
(2) Sometimes
(3) Frequently
(4) Always

6 – Does the test reflect your teacher's work?
(1) Never Occurs
(2) Sometimes
(3) Frequently
(4) Always

7 – Do you find a relation between word problems and your daily life experience?
(1) Never Occurs
(2) Sometimes
(3) Frequently
(4) Always

8 – Do you discuss the solution of a word problem in class?

(1) Never Occurs
(2) Sometimes
(3) Frequently
(4) Always

9 – Do you spend enough time on solving and discussing word problems in class?

(1) Never Occurs
(2) Sometimes
(3) Frequently
(4) Always

10 – Are you able to create a word problem to a friend?

(1) Never Occurs
(2) Sometimes
(3) Frequently
(4) Always

Math Test
Grade 9

Solve the following word problems.

1 – Francis' mother bought him a hat, a pair of shoes, and a suit. The shoes coast twice as much as the hat, and the suit cost 4 times as much as the shoes. How much did each cost if all three cost $33?

Cost of hat	X
Cost of shoes	2X
Cost of suit	8X

2 – Le t x be the price of a poster.
A man bought _ _ _ _ _ _ _ _ poster and _ _ _ _ _ _ _ _ cassettes and _ _ _ _ _ _ _ _ C.Ds. The price of a cassette is _ _ _ _ _ _ _ _ $ less than the price of a poster and the price of a C.D is _ _ _ _ _ _ _ _ $ more than the price of a poster. The total price is _ _ _ _ _ _ _ _ $.
Refer to the given equation to fill in the above blanks.
$x = 4(x-2) + 2(x+1) = 22$

3 -- Mr. Ward bought two tires, one at the regular price and one at a reduction of $2.50. How much did each tire cost if he paid $32.50 for the two tires?

4 -- Mary is two years older than Tom, and Tom is 7 years older than Janis. The sum of their ages is 34. How old is each?

5 – Walid bought 4 pens, 3 copybooks and 2 agendas and paid a total amount of 8850 L.L If the price of a copybook is 500 L.L. more than a pen, and the price of an agenda is 3000 L.L. more than a pen, How much did Walid pay for a pen?
Ziad bought 3 pens, 5 copybooks, and 2 agendas. He paid 11000 L. L Ziad thinks there is a mistake. Justify.

6 – Nada bought stamps for her father. Some cost 3 cents, some 5 cents, and some 13 cents. The number of 5's was 3 times the number of 13's and the number of 3's was 5 less than twice the number of 5's. If she paid $3.53 for the stamps, how many of each kind did she buy?

7 -- Sami bought 5 chairs, 2 tables and 3 desks and Paid $ 950 as a total amount. If the price of the chair is $ 25 less than a table and the Price of the desk is $ 25 more than a table, what is the price of the table.

8 – Farid is 3 years older than Samer, and Samer is 2 years older than Fouad. The sum of their ages is 28 How old is each?

9 – Leila is 4 years older than Rola, and Moha is 3 years younger than Rola. The sum of their ages is 34. How old is each?

10 – Saleh bought 3 pens, 5 pencils and 2 copybooks the price of the pen is twice that of a copybook. The price of the pencil is 100 L.L less than that of the copybook. What is the price of each if he paid 14000 L.L.?