THE EFFECTS OF PROBLEM SOLVING APPROACHES ON STUDENTS' PERFORMANCE AND SELF REGULATED LEARNING IN MATHEMATICS

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ABSTRACT

THE EFFECTS OF PROBLEM SOLVING APPROACHES ON STUDENTS' PERFORMANCE AND SELF-REGULATED LEARNING IN MATHEMATICS

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The main purpose of this study was to investigate the effects of problem solving approaches on pre-service elementary teachers' basic mathematics achievement, problem- solving performance and their self regulated learning.

The study was conducted as quasi - experimental design with 110 elementary school pre-service teachers at a public university in Central Anatolia Region in the 2007-2008 academic year during the second semester. The time duration of the study was 12 weeks. Experimental group was instructed by questioning problem solving approach while control group was instructed by traditional problem solving approach.

The data were collected through Basic Mathematics Achievement Test, Mathematical Problem Solving Test, Motivated Strategies for Learning Questionnaire, Treatment Evaluation Form, interviews and observation checklists.

The quantitative data was analyzed using multivariate analysis of covariance. The results revealed that questioning problem solving approach had a statistically significant effect on pre-service elementary school teachers' basic mathematics achievement, problem solving performance, task value, and control of learning beliefs, metacognitive self-regulation and effort regulation. However, there was no statistically significant mean difference between the experimental and control group in terms of intrinsic and extrinsic goal orientation, self-efficacy for learning and performance, test anxiety, rehersal, elaboration, organisation, critical thinking, time and study environment management, peer learning and help seeking.

In addition the interview results showed that questioning problem solving approach had developed pre-service teachers' skills on Polya's problem solving phase which were devising a plan and looking back. The common opinions among the students about the qustioning problem solving approach that questioning problem solving approach improved their problem solving skills and they learned new ways of solution through class discussions. Moreover, they implied that they learned to think differently.

Keywords: Mathematics education, problem solving, questioning problem solving, self-regulated learning, basic mathematics achievement, problem-solving performance.

ÖZ

PROBLEM ÇÖZME YAKLAŞIMLARININ ÖĞRENCİLERİNİN MATEMATİKTE PERFORMANSLARINA VE ÖZ DÜZENLEMEYE DAYALI ÖĞRENMELERİNE ETKİSİ

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Bu çalışmanın amacı, problem çözme yaklaşımlarının sınıf öğretmeni adaylarının, temel matematik başarılarına, problem çözme performanslarına ve öz düzenlemeye dayalı öğrenmelerini araştırmaktır.

Çalışma, yarı deneysel çalışma olarak 2007–2008 öğretim yılı ikinci yarıyılında İç Anadolu Bölgesindeki bir devlet üniversitesinde 110 sınıf öğretmeni adayı ile gerçekleştirilmiştir. Çalışma 12 hafta sürmüştür. Deney grubuna sorgulayan problem çözme yaklaşımı ile ders işlenirken, kontrol grubunda geleneksel problem çözme yaklaşımı ile ders işlenmiştir.

Veriler, Temel Matematik Başarı Testi, Matematiksel Problem Çözme Testi, Öğrenmede Motive Edici Stratejiler Ölçeği, mülakatlar, Uygulama Değerlendirme Formu ve Gözlem Formu ile toplanmıştır.

Nicel veriler çok yönlü varyans analizi kullanılarak analiz edilmiştir. Sonuçlar, sorgulayıcı problem çözme yaklaşımının öğretmen adaylarının temel matematik başarılarına, problem çözme performanslarına, konu değeri, öğrenme inançlarını kontrol, biliş üstü öz düzenleme ve çaba düzenlemesi değişkelerinde istatistiksel olarak anlamlı bir etkisi olduğunu göstermiştir. Fakat gruplar arasında, iç ve dış hedef yönlendirme, öğrenme ve performansa dayalı öz yeterlik, test kaygısı, tekrar, ayrıntılandırma, düzenleme ,eleştirel düşünme, zaman ve çalışma ortamını düzenleme, arkadaştan öğrenme ve yardım alma değişkenlerin ortalamaları arasında istatistiksel olarak anlamlı bir fark bulunmamıştır. Ayrıca, görüşme sonuçları sorgulayan problem çözme yaklaşımının öğretmen adaylarının Polya’ nın problem çözme aşamalarından planı uygulama ve kontrol aşamalarında problem çözme becerilerinin geliştiğini göstermiştir. Öğretmen adaylarının problem çözme yaklaşımıyla ilgili ortak görüşleri; sorgulayıcı problem çözmenin problem çözme becerilerini geliştirdiği ve sınıf içi tartışmalarla yeni çözüm yolları öğrendikleri yönündedir. Ayrıca farklı şekilde düşünebilmeyi öğrendiklerini ifade etmişlerdir.

Anahtar Kelimeler: Matematik eğitimi, problem çözme, sorgulayıcı problem çözme, öz düzenlenemeye dayalı öğrenme, temel matematik başarısı, problem çözme performansı.

To my parents,
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LIST OF SYMBOLS

MANCOVA	Multivariate Analysis of Covariance
ANCOVA	Univariate Analysis of Covariance
PSM	Questioning Problem Solving Approach
TM	Traditional Problem Solving Approach
BMAT	Basic Mathematics Achievement Test
MPST	Mathematical Problem Solving Test
MSLQ	Motivated Strategies for Learning Questionnaire
IGO	Intrinsic goal orientation
EGO	Extrinsic goal orientation
TV	Task value
COLB	Control of learning beliefs
SELP	Self-efficacy for learning and performance
TA	Test anxiety
REH	Rehearsal
ELA	Elaboration
ORG	Organization
CT	Critical Thinking
META	Metacognition of self regulation
TSEM	Time and study environment management
ER	Effort regulation
PL	Peer learning
HE	Help- seeking
PreMPST	Pretest scores on Mathematical Problem Solving Test
PreBMAT	Pretest scores on Basic Mathematics Achievement Test
PreIGO	Pretest scores on intrinsic goal orientation sub-scale
PreEGO	Pretest scores on extrinsic goal orientation sub-scale
PreTV	Pretest scores on task value sub-scale
PreCOLB	Pretest scores on control of learning beliefs sub-scale

PreSELP	Pretest scores on self-efficacy for learning and performance sub-scale
PreTA	Pretest scores on test anxiety sub-scale
PreREH	Pretest scores on rehearsal sub-scale
PreELA	Pretest scores on elaboration sub-scale
PreORG	Pretest scores on organization sub-scale
PreCT	Pretest scores on critical thinking sub-scale
PreMESR	Pretest Scores on metacognition of self regulation Sub-scale
PreTSEM	Pretest scores on time and study environment management Sub-scale
PreER	Pretest scores on effort regulation Sub-scale
PrePL	Pretest scores on peer learning Sub-scale
PreHS	Pretest scores on help- seeking Sub-scale
PostMPST	Posttest scores on Mathematical Problem Solving Test
PostBMAT	Posttest scores on Basic Mathematics Achievement Test
PostIGO	Posttest scores on intrinsic goal orientation sub-scale
PostEGO	Posttest scores on extrinsic goal orientation sub-scale
PostTV	Posttest scores on task value Sub-scale
PostCOLB	Posttest scores on control of learning beliefs Sub-scale
PostSELP	Posttest scores on self-efficacy for learning and performance sub-scale
PostTA	Posttest scores on test anxiety sub-scale
PostREH	Posttest scores on rehearsal sub-scale
PostELA	Posttest scores on elaboration Sub-scale
PostORG	Posttest scores on organization Sub-scale
PostCT	Posttest scores on critical Thinking Sub-scale
PostMETA	Posttest scores on metacognition of self regulation sub-scale
PostTSEM	Posttest scores on time and study environment management sub-scale
PostER	Posttest scores on effort regulation sub-scale
PostPL	Posttest scores on peer learning sub-scale
PostHS	Posttest scores on help- seeking sub-scale
EG:	Experimental Group

CG	Control Group
df	Degrees of Freedom
α	Significance Level
Sig.	Significance
N	Sample Size

CHAPTER 1

INTRODUCTION

Mathematics is a major part of all areas of daily life, affecting functioning on the job, in school, at home, and in the social community as a whole. Both children and adults confront mathematical problems in their daily lives, as a customer, citizen and worker (Rey et al, 2007).

Increasingly evidence suggests that higher levels of mathematical and technical skills are needed for the majority of jobs in this digital age. As such, we should expect more from our students, not just those planning to pursue higher education, but to ensure that the students we train today have sufficient skills to meet the challenges of this century. Ministry of National Education (MoNE, 2005a) reported that higher mathematical achievement of students is a necessary tool for our national economy and social life. In order to achieve and move forward in this century, our nation needs working people who are mathematically literate, can solve various kinds of problems, think reasonably and can make decisions when needed. As of now, education in mathematics aims to raise individuals who not only know mathematics but also are able to practice the knowledge he/she has, and problem solving (Umay, 2007). The information society of the 21st century requires individuals to go beyond their essential skills and acquire "new competences" which is dwelled on in different works in literature (Altun & Sezgin-Memnun, 2008, MoNE, 2005a; Schoenfeld, 1985). One of these is problem solving. Since problem solving is also a scientific method, it requires the use of critical, creative and reflective thinking, analytical and synthetical skills (Posamentier & Krulick, 1998), left its mark on the current age has a place among the objectives of all courses.

Initially, success in mathematics will stimulate numerous positive developments in various areas of society. Individuals, who like maths are able to think logically, are aware of their learning and are able to develop suitable learning strategies where necessary, and are able to play an important role in the advancement of society (MoNE, 2005a). This is only possible by providing education in this field in order to render individuals approaching the problems they face in their everyday life with different and effective methods of solution. The problem solving approach is the most effective one that can be used to develop these skills (MoNE, 2005a).

The central issue of problem solving in a mathematics curricula has caused maths teachers to attach special importance to problem solving because comprehending mathematical knowledge and establishing relations with this knowledge occur in the process of problem solving (Krulik & Rudnick, 1989).

With the publication of the National Council of Teacher of Mathematics (NCTM, 2000) fourth standards document, *Principles and Standards for School Mathematics* (PSSM), the vision of mathematics teaching and learning to higher standards has evolved. These standard documents call on teachers and students, many of whom still view mathematics as a body of facts and procedures to memorize, to take on very different roles as they strive to achieve complex learning outcomes. Teachers, knowledgeable of the content and of their students' knowledge of the domain, are called to support all students' efforts to understand a coherent, well-articulated curriculum by engaging learners in rich mathematical experiences (Buschman, 2003). In this approach, students are challenged to reason mathematically, to explain and justify their mathematical reasoning, and to construct their mathematical knowledge through exploration and problem solving (MoNE, 2005). New goals have been set forth that include an emphasis on conceptual understanding communicating, reasoning, mathematical understanding, and learning through problem solving and inquiry (NCTM, 2000). Problem solving and reasoning are, and must be, an integral part of any good instructional program (Posamentier & Krulick, 1998). Therefore, maths teachers are in agreement on the issue of improving students' problem solving skills and rendering this to be the primary objective of their education.

Undoubtedly, we face problem solving in not only scientific and mathematical areas but also in all areas of everyday life. We are confronted with situations in which we have to use our creativity to the utmost in order to find original solutions to these everyday problems. We try to attain solutions by using our prior experiences and knowledge. However, in most math classes teachers teach students to solve mathematics problems by having them copy standard solution methods provided by the textbook. Little time is devoted to teaching students how to solve problems. This pushes us to use the same methods of problem solving instead of using our creativity. Considering the fact that one of the objectives of maths education is to provide students with the skills to solve the problems they face in everyday life, problem solving must be rendered the focus of education in mathematics. Investigating how to help students in "mathematics classroom, at every level to become successful problem solvers" has emerged as one of the most important contemporary research issues in mathematics education (MoNE, 2005a).

Problem solving is a complex process that involves multiple variables. They include, but are not limited to, the task, the problem solver, process and environmental factor (Lester, 1983). Problem solving has two products in maths education. The first is the development of strategies and rules special to the taught subject, and the second is the development of ways of thinking and general approaches that can be used to develop a rule or a formula. Students learn to create new strategies by working in problem situations, and solving new kinds of problems by regulating these strategies. Schoenfeld (1987) indicated that students' problem solving failures are often not the result from the lack of knowledge in mathematical content, but rather, self regulatory skills like organization, use and monitoring of knowledge.

Artz and Armour-Thomas (1992) stated that the main reason in problem solving achievement is to monitor the students own mental processes during problem solving. Metacognition may affect how students learn or perform mathematics. Students must learn how to monitor and regulate the steps and procedures used to meet the goal of solving problems.

Although metacognition procedures are rarely the explicit focus of typical classroom instruction, increasing evidence is beginning to indicate that metacognition processes are important components of problem solving (Montague, 1992; Montague, Applegate & Marguard, 1993).

Certain researchers have indicated that metacognitive knowledge is a very important factor that differenciates between a good and an average problem solver (Garofalo & Lester, 1985; Schoenfeld, 1985). Term metacognitive describes the students' awareness and monitoring of what they know and apply during the problem solving process (Schoenfeld, 1985;1987).

The teaching of problem solving in classrooms has been conducted in recent years on the basis of Polya's four-staged model. In practice, even though the order of these stages has not changed, they have been expressed differently and several stages – especially on the evaluation of the solution - have been divided into different sections (Krulik & Rudnick, 1989; Verschaffel et al, 1999). After discussions on the expectations from problem solving education, partial changes have occurred in the problem types worked on, and the interest has shifted towards the problems that are thought to be better at improving metacognitive strategies.

Even though learning how to help students at every level to become succesful problem solvers has emerged as one of the most important issues in mathematics education which is dealth with in literature (Cai, 2000; Cobb, 1994; Lester, 1980, 1994; MoNE, 2005; Schoenfeld, 1992), a single agreed-upon method of regulating the problem solving training does not exist (Posamentier & Krulick, 1998). Research has stated that social constructivist learning environments -in which students can express their opinions on the issue where they have worked on individually or in groups, can share their ideas with other group members and form their own opinions after these interactions - and the contextual learning or employment of these two methods together are more effective than other methods (Schoenfeld, 1985; Verschaffel et al, 1999). Covering the topic within a context includes social interaction and division of labour in teaching, and renders the teaching an activity in which the equipments and cultural assets in the environment participate (Altun & Sezgin- Memnun, 2008). The attempts at reform conducted in recent years confirm these comments in terms of both content and method. In the light of the data, in this study questioning approach to problem solving, which was conducted on the basis of Polya's four-staged model, is used for experimental interventation. More over, this approach is the reflection of social constructivist learning environments - in which students can express their opinions on the issue that is worked on individually or with their peers, can share their ideas with other students and constitute their own opinions. This approach was applied to give students the opportunities to consistently engage in problem solving, discuss their solution strategies and build on their own informal strategies for solving problems.

In addition to this, the role of the teachers on improving the problem solving ability of the students can not be regarded. Moreover, teacher traning programmes play a significant part in obtaining information amd becoming skillfull at problem solving of the teachers. When the teacher’s required characteristics in the ”training-teaching efficiencies” defined by MoNE (2005b) this situation can be better understood. Therefore, pre-service teachers’ education is very crutial since they need to be examined in terms of their knowledge and skills required by new approaches attempts. In this study, pre-service teachers participated as the participants of the study.

On the other way, while mathematics educators and researchers have been trying to understand the impact of classroom contexts on developing mathematical problem solving, educational psychologists are working hard to understand the characteristics of self-regulation and the outcomes of such behavior (Pape & Smith, 2002; Zimmerman, 2000a). Although mathematics educators have found support and direction in socio-cultural theories of learning, their goal of developing mathematics students who actively engage in strategic behaviors and regulate their thinking may require more explicit instruction (Pape & Smith, 2002). Detailed descriptions of cognitive processes, strategic behavior, and intervention studies within self-regulated learning and attribution theories (Schunk, 2001; Zimmerman, 2000a) lend support for and provide examples of explicit strategy instructions that may be embedded within socio-cultural models of instructions in mathematics.

Self regulated learning has been defined and modeled from a variety of theoretical perspectives and frameworks (Ross et al, 2003). One of the most commonly used and frequently cited definitions of self-regulated learning identifies the self regulated learner as one who is behaviorally, metacognitively, and motivationally active in his or her own learning (Zimmerman & Martinez-Pons, 1988). Accordingly to the social cognitive and information processing perspective of self-regulation, Pintrich, Smith, Garcia, and McKeachie (1991) developed and finalized a version of the Motivated Strategies for Learning Questionnaire (MSLQ) to measure some aspects of the self-regulated learning, more specifically motivational beliefs and the use of various learning strategies.

Pintrich (2000) has showed that motivation (i.e., intrinsic motivation and self-efficacy) has a substantial impact upon SRL: adoption of a learning and mastery orientation and positive evaluations of competence lead to greater use of cognitive processing, environmental control/utilization, and metacognition. Motivation includes confidence in one's ability to succeed by exerting strategic effort and recognition that success often comes only after some frustration (Zimmerman, 2000a).

Academic success in mathematics during the elementary and middle school years is critical due to its influence on students' attitudes and motivation towards mathematics. With regards to mathematics learning, research indicates that students who are self-regulated learners have high motivation, low mathematics anxiety and positive attributions and are academically successful learners in mathematics. On the other hand, students who are not self regulated learners, have low motivation, high mathematics anxiety and negative attributions, are academically unsuccessful in mathematics (Missildine, 2004). Much of the research on educational psychology has investigated the presence or absence of discrete SRL skills and documented their impact on academic achievement. Several of these studies have examined the impact on goal setting, self-monitoring, self-efficacy in performance within various domains

(Zimmerman & Kitsantis, 1996; Zimmerman, Martinez- Poins, 1988). This literature has helped us to understand the importance of these specific SRL components for academic achievement and, specifically, mathematics achievement. It has not, however, necessarily helped the classroom teacher to understand his or her role in the development of self-regulation (Pape & Bell, 2003). There has been considerable educational interest regarding the benefits of students' self adjustment as a desirable outcome of an educational process. The PSSM contains five standards, which delineate the content in the mathematics classroom. According to these standards, instructions in mathematics should enable students to "apply and adapt a variety of appropriate strategies to solve problems" and to "monitor and reflect on the process of mathematical thinking". These behaviors are very similar to those discussed within SRL literature, including monitoring progress toward solutions, adjusting behavior depending on observations of progress, reading and listening carefully to ensure understanding, planning frequently, considering alternative strategies; and reflecting on one's progress, among others. Successful problem solvers are strategists in developing an understanding of a problem and forming a concrete or mental problem representation.

Problem solving is perhaps the area of mathematics in which self-regulation is most apparent, therefore, problem solving instructions seem to be an alternative to the traditional approach to help students improve their self regulated learning.

However, there are few experimental research studies done using problem solving and self regulated learning as variables in a mathematics class. So, there is a need for more research to be conducted for this purpose. According to the findings in the literature, the main purpose of research study is; to investigate the effects of questioning problem solving approach on students' mathematical achievement, problem-solving performance and their self-regulated learning, which includes motivational and learning strategies.

In the literature, researcher did not find an experimental study conducted to investigate the effectiveness of questioning problem solving approach on pre-service teachers' achievement, problem-solving performance and self-regulated learning in mathematics education. Considering all these issues, it seems necessary to design an experimental research on the effects of questioning problem solving approach and to explore its effects on pre-service teachers' basic mathematics achievement, problem-solving performance and their self-regulated learning.

1.1 Purpose of the Study

The general purpose of this study is to investigate the effects of questioning problem solving approach on pre-service elementary school teachers' basic mathematics achievement, problem-solving performance and their self- regulated learning. Furthermore, this study has attempted to search the following:

- to examine their usage of Polya' problem solving phases (eg; understanding the problem,devising a plan, carrying out the plan and looking back) during the treatment.
- to investigate the students' opinion with respect to the treatment.

1.2 The Research Questions of the Study

According to this study's purpose, the following research questions were attempted to answer with regards to the participants of this study:

1. What are the effects of questioning problem solving approach compared to traditional problem solving approach on pre-service elementary school teachers' mathematics achievement and problem-solving performance when pre-service elementary school teachers' pre-test basic achievement and problem-solving performance test scores are controlled?
2. What are the effects of questioning problem solving approach compared to traditional problem solving approach on pre-service elementary school teachers' perceived motivation in terms of intrinsic and extrinsic goal orientation, task value, control of learning beliefs, self-efficacy for learning and performance and test anxiety when their pre-test scores of their

perceived motivation are controlled?

3. What are the effects of questioning problem solving approach compared to traditional problem solving approach on pre-service elementary school teachers' perceived use of learning strategies in terms of cognitive and metacognitive strategies; rehersal, elaboration, organization, critical thinking, metacognitive self regulation and resource management strategies; time and study environment management, effort regulation, peer learning and help seeking when their pre-service pre-test scores of their perceived learning strategies are controlled?
4. What are the pre-service elementary school teachers' opinions on the effects of questioning problem solving approach?
5. How does the pre-service elementary school teachers' problem-solving performance change according to the Polya's phases during the study?

1.3 Hypothesis of the Study

The following hypotheses were tested in order to answer the research questions Firstly, related to the first research question the null hypotheses were given.

H_o1: There is no significant overall effect of different problem solving approaches on the collective dependent variables of the pre-service elementary school teachers' post test scores on basic achievement test and problem-solving performance test when participants' pre-test scores on basic achievement test and problem-solving performance test are controlled.

H_o2: There is no significant overall effect of different problem solving approaches on the collective dependent variables of the pre-service elementary school teachers' post test scores on intrinsic and extrinsic goal orientation, task value, control of learning beliefs, self-efficacy for learning and performance, and test anxiety when participants'pre-test scores on each variable are controlled.

H_o3: There is no significant overall of different problem solving approaches on the collective dependent variables of the pre-service elementary school teachers' post test scores on rehersal, elaboration, organization, critical thinking, metacognitive self regulation, time and study environment management, effort regulation, peer learning and help seeking when participants' pre-test score on each variables are controlled.

1.4 Definitions of Important Terms

Problem: A situation for which there is no immediate solution. It is a required analysis and synthesis of previously learned knowledge in order to resolve the question and thus challenges an individual intellectually (Posamentier & Krulick, 1998; Schoenfeld, 1985; Umay, 2007).

Questioning problem solving approach: This approach is a way of teaching problem solving based on Polya's four-phase model and reflection of social constructivist learning environments. In this approach problem solving process is important. By this problem solving approach students can express their opinions on the issue that is worked on individually or with their peers, can share their ideas with other students and constitute their own opinions in problem solving process.

Traditional problem solving approach: Traditional problem solving approach is a way of problem solving focused the solutio in problem solving process. It is teacher-centered problem solving. Teaching problem solving relies on teacher's solution and explanation.

Problem solving performance: Pre-service elementary teachers' performance on the instruments of Mathematical Problem Solving Test.

Basic Mathematics Achievement: Pre-service elementary teachers' scores on Basic Mathematics Achievement Test.

Self-regulated learning**:** This study posits that self-regulated learning is comprised of motivation, cognitive and metacognitive strategies and resource management strategies.

According to Pintrich, Smith, Garcia and McKeachie (1991), goal orientation, intrinsic and extrinsic goal orientation, task value, control and learning beliefs, self-efficacy for learning and performance, rehearsal, elaboration, organisation, critical thinking, metacognitive self-regulation, time and study environment, effort regulation, peer learning and help seeking are defined as follows:

Goal orientation: Goal orientation refers to the student's perception of the reasons why he or she is engaging in a learning task (p.9).

Intrinsic goal orientation: Intrinsic goal orientation concerns the degree to which the student perceives himself/herself to be participating in a task for reasons such as challenge, curiosity, and mastery. Having an intrinsic goal orientation towards an academic task indicates that the student's participation in the task is an end all to itself, rather than participation being a means to an end (p.9).

Extrinsic goal orientation: Extrinsic goal orientation complements intrinsic goal orientation and concerns the degree to which the student perceives himself/herself to be participating in a task for reasons such as grades, rewards, performance, evaluation by others, and competition. When a student is high in extrinsic goal orientation, engaging in a learning task is the means to an end. The main concern the student has is related to issues that are not directly related to participating in the task itself (such as grades, rewards, comparing one's performance to that of others) (p.10).

Task value: Task value refers to the student's evaluation of how interesting, how important, and how useful the task is (p.11).

Control of learning beliefs: Control of learning refers to students' beliefs that their efforts will result in positive outcomes. It concerns the belief that outcomes are contingent on one's own effort, in contrast to external factors such as the teacher (p.12).

Self-efficacy for learning and performance: Self-efficacy is a self-appraisal of one's ability to master a task. Self-efficacy includes judgments about one's ability to accomplish a task as well as one's confidence in one's skills to perform that task (p.13).

Test anxiety: Test anxiety is thought to have two components: a worry or cognitive components and an emotional component. The worry refers to students' negative thoughts that disrupts performance (p.15).

Rehearsal: Rehearsal involves reciting or naming items from a list to be learned. These strategies are best used for simple tasks and activation of information in working memory rather than acquisition of new information in long-term memory. These strategies are assumed to influence the attention and encoding processes, but they do not appear to help students construct internal connections among the information or integrate the information with prior knowledge (p.19).

Elaboration: Elaboration strategies help students store information into long-term memory by building internal connections between items to be learned. Elaboration strategies include paraphrasing, summarizing, creating analogies, and generative note taking. These help the learner integrate and connect new information with prior knowledge (p.20).

Organization: Organization strategies help the learner select appropriate information and also construct connections among the information to be learned. Examples of organizing strategies are clustering, outlining, and selecting the main idea in reading passages (p.21).

Critical thinking: Critical thinking refers to the degree to which students report applying previous knowledge to new situations in order to solve problems, reach decisions, or make critical evaluations with respect to standards of excellence (p.22).

Metacognitive self-regulation: Metacognition refers to the awareness, knowledge, and control of cognition. There are three metacognitive self-regulatory activities: planning, monitoring, and regulating(p.23).

Planning activities such as goal setting and task analysis help to activate, or relevant aspects of prior knowledge that make organizing and comprehending the material easier

Monitoring activities include tracking of one's attention as one reads, self-testing and questioning: these assist the learner in understanding the material and integrating it with prior knowledge.

Regulating refers to the fine-tuning and continuous adjustment of one's cognitive activities. Regulating activities are assumed to improve performance by assisting learners in checking and correcting their behavior as they proceed on a task.

Time and study environment management: Time and study environment management involves scheduling, planning and managing one's study time. Study environment management refers to the setting where student does her class work (p.25).

Effort regulation: Effort management is self-management, and reflects a commitment to completing one's study goals, even when there are difficulties or distractions.

Peer Learning: Peer learning refers to collaboration with one's peer in the learning process (p.28).

Help-seeking: Help-seeking refers to an ability to manage and recognize when help is needed and a certain concept is not well understood. Such help can be from peers, teachers or book search (p.29).

1.5 Significance of the Study

Initially, problem solving is a skill everyone uses throughout life. The teaching and learning of the problem solving process begins as soon as the child enters school, and it must continue throughout school life. The elementary school teacher has the responsibility for beginning problem solving and laying the foundation for the child's future problem solving experiences (Krulik & Rudnick, 1989).

Additionally the teacher's subject matter and content knowledge and skills are also vitally important to the student's achievement (Allen, 2003; Ball, 1989; Ball & Bass, 2003). Carpenter (1989) sees teaching as a problem solving experience. The teacher's interaction with students during the course of classroom instruction creates problems or dilemmas that the teacher must resolve in order to meet the needs of the students. The teacher's knowledge and belief may also influence their decision regarding classroom instructions with students during the course. Ball (2003) pointed out that the quality of mathematics teaching depends on the teachers' knowledge, which effects the quality of work produced by students. Knowing mathematics includes not only knowing the content and concepts that would be taught but also knowing about connections between mathematical concepts and daily life situations how to teach reasoning to students, how to guide in problem solving process, and how to increase their curiosity and interest in class. Since problem solving is a teachable process without qualified, competent teachers; education in mathematics will not improve (Krulik & Rudnick, 1989). If the teacher believes that problem solving means finding one correct mathematical procedure and solution, teacher instructional methods should focus on the mathematical concepts and not on the process of discovering the solution to the problem and students' reasoning. Students' understanding of mathematics, their ability to solve problems are all shaped by the teachers they encounter in the classroom and learn mathematics through the experiences that teachers provide.

On the other way, Post (1992) reported as cited in Silver (1985), teachers' beliefs about teaching mathematics, influence teachers' instructions, which have a profound effect on the students mathematical learning, which indicates that beside this, teachers who have negative attitutes towards mathematics do pass those feelings on their students.

The initial teaching and learning of the problem solving process begins as soon as the child enters school and must continue throughout school life. The elementary school teacher has the responsibility for beginning this instruction and laying the foundation for the child's future problem solving experiences (Krulik & Rudnick, 1989). The problem-solving process is a teachable skill that everyone uses throughout life. The new reform in mathematics education in Turkey confirms these comments in terms of both content and method. The success of such reform attempts depends on the teachers' approval of the reform who will execute these programs, and it is apparent that the attempts will fail if they do not embrace them. Thus, pre-service teachers' education is very crutial since they need to be examined in terms of their knowledge and skills required by these reform attempts. Thus this study will guide pre-service teachers through the problem- solving process.

On the other way, since problem solving is a complex process, there is a wealth of publications about the problem solving in national literature and in the world. For instance, Higgins (1997) presented that the sixth and seventh grade students who had been given the teaching of problem solving have gained positive attitudes. Verschaffel et al. (1999) have found that the teaching of problem solving given to the fourth and fifth grade students has helped them in solving mathematical application problems and students have become able to learn problem solving strategies. Follmer (2000) have reported that the teaching on non-routine problems in the fourth grade has improved the use of cognitive strategies and the awareness of how to solve the problem.

Nancarrow (2004), on three groups each of which consisted of 15 individuals, have examined the influence of a course of problem solving that had been designed to support the original attempts and creativity of students in problem solving on the students' behaviors of solving non-routine algebraic problems.

Altun and Sezgin-Memmun (2008) designed an experimental study to examine the effect of problem solving to prospective mathematics teachers' percieved use of problem solving strategies. Results revealed that the instruction increased the trainees' success of problem solving at different levels and that simplifying the problem, looking for a pattern, reasoning, writing a diagram, making a systematic list, guessing and checking, and working backwards, respectively were the most effective. Korkmaz, Gür and Ersoy (2006) investigated what preservice elementary teachers do in problem posing process, and to determine the misunderstandings that they have in this process. The findings showed that first of all preservice teachers did not know the difference between problem and exercise. They defined problems to be the exercises solved at the end of lesson in order to practice the introduced idea.

Tanrıseven (2000) conducted an experimental study to investigate the effect of problem solving with dramatization. Results of the study indicated that the there was a significant difference between traditional problem solvingand problem solving with dramatization. Arslan (2002) examined the learning and using of problem solving strategies in the seventh and eighth grade students. It was reported according to the results, problem solving strategies can be learned by seventh and eighth grade and the problem solving education had appositive effect on students' attitutes towards problem solving. Posluoğlu-Yıldız (2002) conducted an experimental study in her study to compare the differences of experimental and control groups students at fifth grade with cooperative learning technique and traditional technique according to the problem solving skills. Results showed that cooperative learning technique developed students problem solving skills.

According to the studies in literature it can be said this study is parallel to studies conducted by using problem solving with respect to teaching problem solving strategies, but is different from examining the questioning problem solving approach. This approach is basis on Polya's problem solving framework but was wealthed by using social contructivism and teaching problem solving strategies. In addition it can be emphasized that very little research has been conducted related to pre-service teachers. From this point of view it seems crucial to conduct experimental study to investigate the effectiveness of questioning problem solving approach on first grade pre-service teachers.

On the other side, self-regulation is important because a major function of education is the development of lifelong learning skills. In daily life every person attempts to self-regulate his or her functioning in some way to gain goals in life and that it is inaccurate to speak about un-self-regulated persons or even the absence of self-regulation. The regulation of one's health and stress management, which in turn covers lower level activities such as strategy use self-observation are all related terms with respect to self-regulation (Ross et al, 2003).

Self-regulation refers to the students' ability to understand and control their learning. Students of all ages need to control their learning through productive motivational beliefs and use of cognitive learning strategies. Self-regulated learning has been demonstrated to be a significant predictor of academic success in many researches (e.g.; Zimmerman & Martinez-Pons, 1988). In fact, SRL may be especially relevant for complex problem solving, which requires metacognition and perseverance in the face of challenge (De Corte et al., 2000). Many studies (e.g., Lester & Garofalo, 1982; Schoenfeld, 1992) illustrate how self-regulation differs between weak and skilled problem solvers.

Although, there is a wealth of publications about the components of self-regulation and their effects on mathematical achievement, few experimental studies explain which approach should be applied for developing self-regulation training or which approach is efficient in a mathematics class.

All students are expected to acquire sufficient mathematical problem-solving skills in order to be well prepared for most of this century that needs high mathematical thinking and technical skills (MoNE, 2005a). However, students manifest serious deficits in problem solving and self-regulation. Thus, there is a need to conduct an experimental research in problem solving for pre-service teachers investigating the effectiveness of their self-regulated learning.

This study was designed design to fill that gap by combining all these important elements into one experimental study to create a more complete picture of pre-service teacher education as teachers need to develop their own problem–solving performance and mathematical self-regulated learning which involves motivation and learning strategies. Additionally, it will guide pre-service teachers through the problem- solving process.

1.6 Assumptions

1. All tests were administered to the experimental and control group under the same standard conditions.
2. The groups that were subject of the study responded honestly to the test items and interview questions.
3. Subjects from both groups were not allowed to interact or communicate with each other.

1.7 Limitations

1. The first grade pre-service elementary teachers who participated as subjects in the study do not represent typical pre-service elementary teachers of elementary teacher education departments in national universities. The participants entered the university with high mathematics scores. The department is ranked first with the highest score in national university entrance exam called OSS. Therefore, the results can be generalized for first grade elementary school education students at similar placed universities.
2. The results of the study were limited to the population with similar characteristics, thus the results were only representative of that group.
3. The study was limited to the course "Basic Mathematics Course II" in the curriculum of elementary teacher education.
4. The researcher acted as a mathematics teacher in both experimental and control groups. Therefore, there may have been a bias favoring the implementation of treatment instructions in treatment groups. To avoid this, two observers were participated in the study. They observed both the experimental and the control group. The results of the observation checklists were used as evidence for eliminating bias.
5. Another limitation of the study was not using random selection. Considering the administration and limitation of official permission, groups were not assigned randomly, thus two existing classes from division of elementary teacher education were used. Thus the study was not a true experimental study since subjects were not randomly assigned to the experimental and the control groups .
6. Lastly, even though a single agreed-upon approach of regulating the problem solving does not exist, this study is limited to the problem solving approach that is otlined in this study. This present study, basically Polya's problem solving phases, were used with respect to a new approach. This questioning approach is the reflection of social constructivist learning environments - in which students can express their opinions on the issue that is worked on individually or with their peers, can share their ideas with other

students and constitute their own opinions. Thus, the results could be generalized to problem solving that is defined and used in this present study.

CHAPTER 2

REVIEW OF THE LITERATURE

In this chapter, first the background to the problem and problem solving are outlined. It covers with the cognitive and metacognitive in problem solving and the framework of problem solving. Later, explanations on self regulation, self regulated learning and related literature are presented.

2.1 Background of Problem and Problem Solving

Krulik and Rudnick (1989) defined a problem as: “a definition is a situation, quantitative or otherwise, that confronts an individual or group of individuals, that requires a solution, and for which the individuals sees no apparent path to the solution. The key to this solution is the phase “no apparent pattern”. To Van De Walle (2007), a problem is a task or activity for which the students have no prescribed or memorized rules or methods nor is there a perception by students/a student that there is a specific correct method for solution.

Having a problem means “to have a problem:” to search consciously for some action appropriate to attain a clearly conceived, but not immediately attainable aim” (Polya, 1962).

Krulik and Rudnick (2003) explain the distinctions between questions, exercise and problem as follows:

(a) Question: a situation that can be resolved by mere recall and memory

(b) Exercise: a situation that involves drill and practice to reinforce a previously learned skill or algorithm.

(c) Problem: a situation that requires analysis and synthesis of previously learned knowledge to resolve.

Polya (1962) states that “solving a problem means finding a way out of a difficulty, a way around an obstacle, attaining an aim which is not immediately attainable”. The heading problem implies that the individual is being confronted by something he or she does not recognize (Krulik & Rudnick, 1989).

More over, a situation will no longer be considered a problem once it has been modeled or can easily be solved by applying algorithms that have been previously learned. A problem is something a person needs to figure out, something where the solution in not immediately obvious. Solving problems requires creative effort and higher level thinking (Krulik & Rudnick, 1989).

So from different sources (Altun, 1998; Krulik & Rudnick, 1989; Polya, 1962; Schoenfeld, 1985; Umay, 2007) it can be said that a problem is:

- A situation in which a solution is not apparent
- Requires thoughts and synthesis previously learned in order to resolve it.
- A difficulty for the person who faces it.
- A situation that the individual needs to solve.
- An individual that has not faced the problem situation before and he or she is not prepared to solve it.

The individual needs to feel a desire and to expend energy to solve the problem.

From all of these definitions it seems clear that mere recalls of facts or applications of previously learned algorithm does not lead to a solution. It implies that in order to solve the problem, the problem solver will need to apply knowledge and skills in order to construct the solution. If the solution is seen as easy, it is implied that the problem is not a problem for the problem solver. The problem below is given as an example:

"*A man was making out his will. He had 1,600 dollars to divide among his three sons. The oldest was to get 200 dollars more than the middle son. The middle son was to get 100 dollars more than the youngest son. How much did each son get*?"(Posamentire & Krulick, 2009*)*.

This sample problem is not thought of as a *problem* for most adults though the answer is apparent, thus it could be thought of as a *problem* for elementary level students, since they have to do something to resolve the issues and construct the knowledge needed to solve the problem.

If a student sees the answer to a problem, then it is not really a problem for that student (Rey et al, 2007). What might be a problem for one individual might not be a problem for another. If the student refuses to accept the challenge, it is not a problem for that student at that time; a problem must be perceived as such by the student, regardless of the reason, in order to be considering a problem by him or her (Van De Walle, 2007). A situation will no longer be considered a problem once it has been modeled or can easily be solved by applying algorithms that have been previously learned (Krulik & Rudnick, 1989).

A mathematical problem can be defined by using the definition of a problem: A mathematical problem is a problem which requires mathematical thinking, challenge and a synthesis of previously learned mathematical constructs (Umay, 2007). A mathematical problem should contain important content and should engage interest in students and well crafted. Mathematical construct, mathematical thinking and reasoning are the key points of a mathematical problem.

2.2 Problem Solving in Mathematics Education

Investigating to make students good problem solvers is not a new concept in mathematics education. Over the years, problem solving has emerged as one of the major concerns at all levels in school mathematics (Posamentier & Krulick, 2009). It has been frequently cited in many research related to mathematics curriculum throughout the years (Polya, 1957, 1962, 1973; Schoenfeld 1985). Problem solving is now being considered a measure of true mathematical understanding, Additionally, it is considered a skill that is important across subjects areas and situations (MoNE, 2005a; Umay, 2007).

Learning how to help students at every level to become successful problem solvers has emerged as one of the most important contemporary research issues in mathematics education. Because the development of student problem solving abilities has been identified as a fruitful source of improvement, it is imperative that we strive to more fully understand the complex underlying cognitive, affective, and social mechanisms that successful problem solvers employ.

In recent years, the NCTM, in its Principles and Standards for School Mathematics notes that in the upper elementary grades, The goal of school mathematics should be for all students to become increasingly able to and willing to engage with and solve problems (NCTM, 2000; Posamentier and Krulick, 1998).

> *A problem-centered approach to teaching mathematics uses interesting and well-selected problems to launch mathematical lessons and engage students. In this way, new ideas, techniques and mathematical relationship emerge and become the focus of discussion. Good problems can inspire the exploration of important mathematical ideas, nurture persistence and reinforce the need to understand and use various strategies, mathematical properties and relations (NCTM, 2000 p.52).*

Polya (1973) defined problem solving as searching for an appropriate course of action to attain an aim that is not immdediately attainable. From a broader perspective, problem solving involves reaching a goal by providing an answer to a given state in which an answer or solution method is not initially known (Mayer, 1982; Pugalee, 1995).

Problem solving can be a vehicle used to introduce our students to the beauty that is inherent in mathematics but it can be also be the unifying thread that ties their mathematics experiences to gather into a meaningful whole (Posamentier & Krulick, 1998). Polya, (1973) stated that the major theme of doing mathematics was problem solving and that it was important to teach students to think. Most, if not all, important mathematical concepts and procedures can best be taught through problem solving (Van De Walle, 2005).

In the literature much of the research on mathematical problem solving have been influenced by mathematician George Polya and his book, “How to solve it,” 1957.

> *“A great discovery solves a great problem but there is a grain of discovery in the solution of any problem. Your problem may be modest; but if it challenges your curiosity and brings into play your inventive faculties, and if you solve it by your own means, you may experience the tension and enjoy the triumph of discovery (Polya, 1957, p.v).”*

Students are seldom given opportunities to solve challenging mathematical problems in mathematics classrooms. They infrequently engage in mathematical reasoning, conjecturing, communicating or proving. Students may be able to follow algorithms that can range from recognizing a problem as very similar to one previously solved, to taking on a homework exercise similar to exercises presented in class,. but only a few uderstand wht they are really doing or why they are performing these activities (Campione, Broen & Connell, 1989). They tend to tackle problems based upon their previous experiences. When faced with problems of slightly greater diffulty, students often perform poorly. Students are not doing any problem solving rather they are merely practicing the earlier encounter situation (Posamentier & Krulick, 1998). They may try to acquire minimal information from classroom instruction in order to pass their school test, but most never acquire a deep understanding that results in useable and transferable knowledge (Segal, 1996). Both children and adults confront mathematical problems in their daily lives, as a costumer, citizen and worker, so mathematical problem solving is a skill people need throughout their lives. In spite of the relationship between a mathematics class and quantitative situations in life, students see little connection between what happens in school and what happens in real life. An emphasis on problem solving in the classroom can lessen the gap between the real world and the classroom world and thus set a positive mood in the classroom (Krulik & Rudnick, 1989). Problem solving is natural to young children because the world is new to them, and they exhibit curiosity, intelligence and flexibity as they face new situations. The MoNE (2005a) mentioned the importance of appealing problems and stated that mathematical concepts can be introduced through problems that come from their worlds. The use of real life and meaningful problems enhance the students' problem solving experience.

Problem solving is a process. It is the means by which an individual uses previously acquired knowledge, skills and understanding to satisfy the demands of an unfamiliar situation. The process begins with the initial confrontation and concludes when an answer has been obtained and considered with regard to the initial conditions. The student should synthesize what he or she has learned and apply it to the new and different situation (Krulik & Rudnick, 1989).

The problems chosen in a maths course should be interesting and relevant to the issues that students need in their daily lives and to their school activities. Thus, the mathematical knowledge and skills that students obtain will be more meaningful and it will be easier for them to use this knowledge in different situations. Students should be able to use different problem solving strategies while problem solving. They should understand the importance of planning, controlling and using different strategies (MoNE, 2005a). As students become successful in the process of problem solving and feel that their solution methods are appreciated, their self-confidence about mathematics will increase(MoNE, 2005a).

The Elementary Schools Curriculum, targeted to improving the following skills in students while providing them with problem solving skills (MoNE, 2005a).

- Using problem solving to analyze and understand mathematical concepts,
- Problem solving by using mathematical and everyday life situations,
- Controlling and interpreting the solutions' plausibility and suitability to mathematics
- Using different problem solving strategies to solve different problems, for example, trial and error, using image table, materials, searching for patterns, estimating and controlling and working backwards.

It has been determined that traditional verbal problems do not improve the problem solving skills of students. The solutions that students find through acting according to several pattern words in problem sentences is not very meaningful for students and the real life situations that are relevant to the problem are not taken into consideration in the problem solving process (Verschaffel & De Corte , 1997).

Various researchers (Lesh & Doerr, 2003; Schoenfeld, 1992; Verschaffel et al, 1994) focus on mathematical modeling problems as problem solving activities that are open-ended, not directed with pattern sentences, non-routine, and enabling students to work on real life situations and thus, raising students as individuals who have strong problem solving skills out of school and in their future lives.

The teaching of problem solving in a classroom has been conducted in recent years on the basis of Polya's four-staged model. In practice, even though the order of these stages has not changed, they have been expressed differently and in several stages - especially the stage on the evaluation of the solution and divided into more parts. (eg, Garofalo & Lester, 1985; Schoenfeld, 1985).

Many theoretical papers and research studies (eg, Garofalo and Lester, 1985; Lester 1983; NCTM, 2000; Pintrich, 2002; 1982; Schoenfeld, 1985,1987; Davidson & Sternberg, 1998; Zan, 2000) have suggested that student's low problem solving performance is associated with more then just a lack of content knowledge. These authors have also pointed to students' inability to (1) organize knowledge already possessed, (2) plan strategies for implementing what is known, and (3) monitor the effectiveness of these strategies as factors adversely affecting problem-solving performance.

Along with these changes related to problem solving, important changes have also occurred in the issue of what is understood from mathematics; and started to be considered to be a set of problem solving and interpretation activities that are basically based on the modeling of the reality, rather than a collection of abstract concepts and knowledge that needs to be learned (MoNE, 2005a). Thus, the aim of learning mathematics is to provide students with mathematical predisposition rather than isolated concepts and skills. These basic evaluations bring to the agenda the issues of how an appropriate teaching of problem solving should be planned and how the learning environment should be prepared. Even though a single agreed upon method of regulating the problem solving training does not still exist, researches have presented social constructivist learning environments -in which students can express their opinions on the issue that is worked on individually or in groups - can share their ideas with other group members and constitute their own opinions after these interactions- and the contextual learning or employing these two methods together are more effective than other methods (Verschaffel et al,1999). Students should be encouraged to share their thinking, their solution strategies as well as their solutions with their peers and teachers. If students are unable to solve a problem, talking with their peers or with the teacher may provide the students with small amount of help that will be the impetus needed to put them onto the path of solving the problem. The whole process of problem solving enhances the reasoning skills of the students, because to explain it another, why one did what one did and why one thinks, requires more reasoning skills than is does to do the problem (Rey et al, 2007).

Covering the topic within a context includes social interaction and division of labor in teaching, and renders the teaching activity an activity in which the equipments and cultural assets in the environment participate .

2.3 Cognition and Metacognition

Metacognition refers to one’s knowledge of one’s own cognitive process and products, which may include self- questioning, self- monitoring, self-regulation or evaluation procedures (Montague, 1992; Mantague, 1993). Metacognition strategies focus on students thinking and generally become more aware of the various processes they use to solve problems. Increasing evidence is beginning to indicate that metacognition processes are important components of problem solving, however metacognition procedures are rarely the explicit focus of typical classroom instruction (Montague, 1992; Montague, Applegate & Marguard, 1993; Silver & Marshall, 1990)

According to Schoenfeld (1985), control deals with selecting and deploying the resources at one's disposal. Additionally, metacognitive control deals with the regulation of cognitive activities and is the mechanism students use while deciding when, how, and if they will use the mathematical facts and procedures at their disposal for planning, monitoring, and checking activities (Schoenfeld, 1985).

Metacognition refers to higher order thinking which involves active control over the cognitive processes engaged in learning. Activities such as planning how to approach a given learning task, monitoring comprehension, and evaluating progress toward the completion of a task are metacognitive in nature (Livingston, 1997).

The terms self-regulation, monitoring, control, and executive decision are frequently used throughout the literature to describe the concept of metacognition (e.g., Schoenfeld, 1985, 1992). Metacognition can be divided into two distinct components: metacognitive knowledge and metacognitive control. Metacognitive knowledge is awareness of one's cognition, which is a personal awareness of how one thinks. Metacognitive control consists of planning, evaluating, monitoring, and verifying cognitive activities (Lester, Garofalo & Kroll, 1989; Livingston, 1997; Schoenfeld, 1985; 1992). It involves decisions that problem solvers make regarding when, if and how they could use their resources. According to Brown et al (1983) as cited in Schoenfeld (1985), define metacognitive control components as planning (prior to understanding), monitoring (during learning) and checking outcomes.

Some studies have reported that student problem solving performance is directly linked to how actively and efficiently students employ their metacognitive control mechanisms (Schoenfeld, 1985; 1992). Besides this, it was stated that metacognition has been identified as an important factor in the problem-solving process (Harskamp & Suhre,2007; Schoenfeld, 1985). To Van De Walle (2006) good problem solvers monitor their thinking regularly and automatically. Good problem solvers make conscious decision to switch strategies, re-think the problem, and search for related content knowledge that may help or simply start afresh (Schoenfeld, 1992).

Pugalee (2001) has concluded that successful students differed from others in terms of their behavior of focusing on the problem, organizing the data, performing a transaction and interpreting the results. Pape and Wang (2003) have concluded that the elementary school second grade students differed from others with their behavior of selecting a target, making a plan, regulating their own behaviors, regulating the studying environment for themselves, evaluating themselves with others student’s assistance.

Metacognition enables students to coordinate the use of current knowledge and of reflective strategies to accomplish a single goal. Metacognitive awareness, therefore, serves a regulatory function and is essential to effective learning because it allows students to regulate numerous cognitive skills (Howard, McGee, Shia & Hong, 2000).

2.4 Conceptual Framework of Problem Solving

Problem solving has only recently gained the increased attention of the mathematics education community, though problems and problem solving were always viewed as part of mathematics. Since then, numerous researchers and organizations documented continued interest in problem solving by emphasizing its various aspects in mathematics teaching and learning. In this section, as a part of this research, several descriptions of problem solving have been used.

An early description of problem solving was outlined by George Polya in his four phase model in his book "How to solve it." Most of the work that followed has been an enhancement and modification of Polya's fundamental ideas, all of which are used today. Polya's stages are well-known and are also taken into account and constructed a theoretical basement for the present study.

Polya (1954) defined mathematical problem solving as a process that involves several activities and the use of "heuristics" as a plan for solving problems. Heuristics is the process by which a problem solver attempts various approaches to find the solution to a problem. Polya's heuristic model contains four steps which has long served as a guide for teaching problem solving and investigating problem solving skills. Polya's model of the problem solving process is as follows:

1. Understand the problem; define the problem by identifying various problem basics and how they are related;
2. Devise a plan; examine the different elements of a problem from a variety of ways to identify a solution method that will work;
3. Carry out the plan; carry out the chosen strategy and evaluate the accuracy through reasoning;
4. Look back; applying and reflecting on the results and consequences, asking if a

different method could be applied.

Schoenfeld (1985), devised a model for analyzing mathematical problem solving that derived form Polya' work. He developed a model in five episodes: reading, analysis, exploration, planning/implememtation and verification. In this model, protocals are called episodes. Each episode represents a period of time during which an individual or group of problem solvers are engaged in a task and consistently display one form of behavior .

Garafola and Lester (1985) built on Polya's (1945) and Shoenfeld's (1985) structures by developing a framework for analyzing metacognitive aspects of performance on a wider range of tasks. Their cognitive-metacognitive framework is comprised of orientation, organization, execution and verification. An important aspects of their phases is distinctive metacognitive behavior associated with each category.

Arzt and Armour-Thomas (1992) developed another cognitive-metacognitive framework which attempted a synthesis of the problem-solving steps identified by Garofalo and Lester, Polya and Schoenfeld. Their episodes are: (i) reading, (ii) understanding, (iii) analysis, (iv) exploring, (v) planning, (vi) implementing, (vii) verifying, (viii) watching and listening.

Montague (2003) defined cognitive process and metacognitive strategies in a problem solving process. This process comprised of: read, paraphrase, visualize, estimate, compute and check. This process is based on developmental and information processing theories.

There is no single set of heuristics for problem solving, although several people have put forth workable models. An important one is that students learn some sets of carefully developed heuristics, and develop the habits of applying these heuristics in all problem-solving situations (Krulik & Rudnick,1989).

2.5 Problem Solving Strategies

Schoenfeld (1992) indicated that students' problem solving failures are oftentimes attributed to the unproductive use of strategies that help students to build their own knowledge. He suggested giving students strategies such as searching for patterns, drawing diagrams, listing all possible answers would help students become problem solvers. Students would develop a range of strategies and thus be able to choose the appropriate strategy to match the problem solving task (Kloostermen and Stage, 1992). The reason for being unsuccessful problem solvers is not only the lack of mathematical content but also unproductive use of strategies.

Posamentier and Krulik (1998) list the major problem solving strategies that can be used in solving mathematical problems as (p.4-5) :

1. Working backwards
2. Finding a pattern
3. Adopting a different point of view
4. Solving a simpler, analogous problem (specification without loss of generality)
5. Considering extreme cases
6. Making a drawing (visual representation)
7. Intelligent guessing and testing
8. Accounting for all possibilities
9. Organizing data
10. Logical reasoning

These strategies are not the only ones available but they present those most applicable to mathematics instructions in the school. In the mathematics classroom strategies provide an alternative plan for resolving many problem situations that arise within the curriculum.

Sometimes teachers are not aware of the numerous problem solving strategies that can be used to provide efficient and elegant solutions to many problems. Students should be exposed to traditional problem solving strategies as additional ways of problem solving, instead of being taught that these strategies are the only ways problems can be solved. Direct instruction of problem solving strategies can take place after students have created their own strategies for solving a wide range of problems (Buschman, 2003). Polya (1953) suggested that problem solving could be introduced as a practical art, like playing piano, as an act of inquiry and discovery to develop students' abilities to become skillful problem solvers and independent thinkers. Thus, it is expected that the problem solving approach to mathematics instructions will provide a vehicle for students to construct their own ideas about mathematics, to take responsibility for their own learning and their self- regulated learning (MoNE, 2005a).

Higgins (1997) stated that sixth and seventh grade students who had been given the teaching of problem solving had gained positive attitudes. Verschaffel et al. (1999) have found that the teaching of problem solving given to fourth and fifth grade students has helped them in solving mathematical application problems and that students have been able to learn problem solving strategies.

Altun and Sezgin-Memmun (2008) designed an experimental study to examine the effect of problem solving to prospective mathematics teachers' percieved use of problem solving strategies. Results revealed that the instruction increased the trainees' success of problem solving at different levels and that simplifying the problem, looking for a pattern, reasoning, writing a diagram, making a systematic list, guessing and checking, and working backwards, respectively were the most effective.

Arslan (2003) conducted an experimantal study to investigate problem solving strategies training on seventh and eighth grade elementary students. The results showed that seventh and eighth grade students could learn problem solving strategies.

It is important to distinguish between Polya's model itself and solving strategies. Polya's four stages provides a general picture of how to move through the process of solving a problem, whereas strategies are tools that may be useful at various points in the problem solving process (Rey et al, 2007).

2.6 The Role of the Teacher in Problem Solving

NCTM defines the teacher's role as one of promoting a problem solving approach to the learning of all mathematics content. "The teachers role in choosing worthwhile problems and mathematical tasks is crucial" (NCTM, 2000, p. 53). In many cases students seem to feel that a problem can only be solved in a specific way, specific to the type of problem being taught. Students often feel that an algebraic approach is the only procedure that will work (Posamentier and Krulick; 1998). In fact, it is often the teacher themselves who are not aware of the many problem solving strategies that can be used to provide efficient and elegant solutions to many problems. It is often they who unconsciously convey to their students the notion that problem can only be solved using an algebraic approach.

As Buschman (2003) mentioned, the role of the teacher in problem-solving classroom is:

- Creating a classroom environment that supports and facilitates learning how to become a problem solver.
- Posing challenging problems for student to solve.
- Facilitating discussions and help a student understand each solution.
- Modeling how to ask questions that encourage clear and complete explanations such as “I do not understand.”
- Using student’s solutions to reinforce learned skills or teach new skills.
- Asking probing and encouraging questions.

Certain mathematics teachers plan to teach problem solving as a seperate topic where students may apply skills that have already been taught. Problem solving is not just a method in mathematics, but a major part of learning mathematics (MoNE, 2005a). The teacher should use well selected problems to engage students and launch mathematical lessons. In NCTM (2000) “good problems can inspire the exploration of important mathematical ideas, nurture persistence and reinforce the need to understand and use various strategies, mathematical properties and relationship. Therefore, different ideas, different answers, mathematical relations could emerge and become the main point of the discussion.

Teachers should engage students in mathematical discourse about problem solving which includes discussing different solutions and solution strategies for a given problem and how solutions can be extended and generalized. “Teachers play an important role in the development of students’ problem-solving dispositions by creating and maintaining a classroom environment, in which students are encouraged to explore, take risks share failures and successes and question one another. In such supportive environments students develop confidence in their abilities and explore problems and will be more likely to pose problems and persist with challenging problems" (NCTM, 2000, p.53).

Buschman (2003) stated that teachers sometimes are not aware of the numerous problem solving strategies that can be used to provide efficient and elegant solutions to many problems. Students should be exposed to traditional problem solving strategies as additional ways of problem solving instead of being taught that these strategies are the only way problems can be solved. Direct instruction of problem solving strategies can take place after students have created their own strategies for solving a wide range of problems.

In addition, teachers can ensure that they help all children with problem solving including their special needs, by managing their time, managing the class routines appropriately and assisting student needs by using compensatory strategies to adjust instructions to the needs of individual students (Rey et al, 2007).

Teachers should help students become problem solvers by selecting rich and appropriate problems, orchestrating their use, and assessing students understanding and use of strategies (NCTM, 2000). Additionally, teachers should not limit students to using only the strategies that are discussed in the classroom; they should always encourage students to generate their own ideas about how to approach new situations. If some students are successful using a strategy that has have not been discussed, teachers should encourage them to share their ideas with the rest of the class (Rey et al, 2007).

It is indicated in the MoNE (2005) that teachers should select problems which are interesting and useful for their students, that teachers are expected to value different ways of solution to the problems, and give more importance to students' strategies instead of merely focusing on the right answers.

2.7 Definition of Self-Regulation According to Different Approaches

Bandura (1986) defined self-regulation, as the ability to control our own behavior and that it is the workhorse of human personality. Bandura suggests three steps: (1) Self-observation, we look at ourselves, our behavior and keep tabs on it; (2) Judgment, we compare what we give or we see with a standard, (3) Self-response, if we did well, compared to our standard, we give ourselves rewarding self-responses. If we did poorly, we give ourselves punishing self-responses. Self-regulation refers to self-generated thoughts, feelings and behaviors that are oriented to attaining goals (Zimmerman, 2000a). These learners are proactive in their efforts to learn because they are aware of their strengths and limitations and because they are guided by personally set goals and task related strategies, such as using an arithmetic addition strategy to check the accuracy of solutions to a subtraction problem.

According to Pintrich (2004), self-regulation is an active constructive process whereby learners set goals for their learning and then attempt to monitor, regulate and control their cognition, motivation and behavior, guided and constrained by their goals and the contextual features in the environment.

According to a recent definition, self-regulation is conceived of as an overarching construct covering certain aspects, such as self-regulation the regulation of one's health and stress management, which in turn covers lower level activities such as use of strategy and self-observation (Ross et all, 2003).

Self-regulation is important because a major function of education is the development of lifelong learning skills. After graduation from high school or college, young adults must learn many important skills informally. For example, in business settings, they are often expected to learn a new position, such as selling a product, by observing the proficiency of others and by practicing on their own. Thus, in daily life every person attempts to self-regulate his or her functioning in some way to gain goals in life and that it is inaccurate to speak about unself-regulated persons or even the absence of self-regulation (Zimmerman, 2000a).

2.8 Self-Regulated Learning (SRL)

Self regulated learning has been defined and modeled from a variety of theoretical perspectives and frameworks (Ross et al, 2003). One of the most commonly used and frequently cited definitions of self-regulated learning identifies the self regulated learner as one who is behaviorally, metacognitively, and motivationally active in his or her own learning (Zimmerman and Martinez-Pons, 1988).

Research into self regulated learning has produced a variety of theoretical models in an effort to identify the many variables that make up this multifaceted construct. Among these models are Biggs' (1978, 1985) model of metalearning, Zimmerman's (1989, 2000) social cognitive view of academic self regulation, Winne' s (1995) Four Stage Model of Self Regulated Learning, and Pintrich's (2000) general framework for self regulated learning.

Based on Bandura's (1986) triadic model, a social cognitive perspective of self-regulated learning views self regulation as the interaction of personal, behavioral and environmental processes. Further expanding on this triadic model, Zimmerman (2000) asserts that from a social cognitive perspective, self regulatory processes occur through three phases: forethought, performance or volitional control and self regulation processes. The forethought phase includes such processes as goal setting, strategic planning and self motivational beliefs. The second phase of self regulation, performance or volitional control includes such processes as self instruction and implementing task strategies. The third phase includes such processes as self judgment and self evaluation.

According to Zimmerman (1989), the development of self regulation is dependent upon social, environmental, and behavioral triadic influences. There are four levels of development of self-regulated learning: observation, imitation, self-control, and self-regulation. Novice learners acquire self-regulated learning skills mainly through observing models and receiving proper feedback. When the learner's performance approximates the model, an imitative level is attained. The learner's use of self-regulated learning strategies has become internalized at this stage but still not fully independent of the model's performance. The fourth stage is not attained until the learner is capable of systematically adapting the learning strategies to changing personal and contextual situation.

Pintrich (1989) synthesizes some of the various models of self regulated learning in an effort to develop a general framework. According to the framework SRL, there are four phases of self regulation: forethought, planning and activation; monitoring; control; and reaction and reflection. The first phase includes the learner’s perceptions and knowledge of the task. The second phase, involves metacognitive processes such as planning. The third phase, involves such processes as the selection and adaptation of cognitive strategies. The fourth phase, reaction and reflection, involves reflections on both aspects of the self and of the learning context.

At each phase, the learner regulates cognition, motivation\affect, behavior, and the learning context. Hence, according to Pintrich’ (2004) synthesis, in phase 1, the learner engages in such processes as developing perceptions of the task including task demands and activating his or her prior knowledge. This framework is presented in Table 2.1.

Table 2.1 Areas for Regulation

Phases & relevant scales	Cognition	Motivation/ Affect	Behavior	Context
Phase I Forethought planning activation	Target goal setting Prior content knowledge activation Metacognitive knowledge activation	Goal orientation adoption Efficacy judgments Perception of task difficulty Task value activation Interest activation	Time and effort planning Planning for self-observations of behavior	Perception of task Perception of context
Phase II Monitoring	Metacognitive awareness and monitoring of cognition	Awareness and monitoring of motivation and affect	Awareness and monitoring of effort, time use, need for help Self-observation of behavior	Monitoring changing task and context conditions
Phase III Control	Selection and adaptation of cognitive strategies for learning, thinking	Selection and adaptation of strategies for managing, motivation, and affect	Increase/decrease effort Persist, give up Help seeking behavior	Change or renegotiate task Change or leave context

Table 2.1 (continued)

Phase IV Reaction and reflection	Cognitive judgments	Affective reactions	Choice behavior	Evaluation of task
Relevant MSLQ Scales	Attributions Rehearsal Elaboration Organization Critical Thinking Metacognition	Attributions Intrinsic Goals Extrinsic Goals Task Value Control Beliefs Self-Efficacy Test Anxiety	Effort Regulation Help-Seeking Time/Study Environment	Evaluation of task Evaluation of context Peer Learning Time/Study Environment

As seen from Table 2.1, in phase 2, during monitoring, the learner engages in such processes as metacognitive monitoring. In phase 3, the learner selects and implements appropriate cognitive strategies in response to task demands. Finally in phase 4, the learner must evaluate his or her task performance, make attributions for his or her successes and failures, and reflect on the effectiveness of his or her cognitive and motivational strategies.

In this study, Pintrich's (2000) general framework for self regulated learning will be used as a theoretical base based. According to this framework there are four phases of self regulation: forethought, planning and activation; monitoring; control; and reaction and reflection, and the cognition, behavior and context areas contributed as a basis in this study.

2.9 Self-regulatory Strategies

Although there are a number of different models derived from a variety of different theoretical perspectives, most models assume that an important aspect of self-regulated learning is the students'use of various cognitive and metacognitive strategies to control and regulate their learning.

Rehearsal, elaboration and organizational strategies were identified as important cognitive strategies related to academic performance in the classroom. Rehearsal strategies involve the recitation of items to be learned or the saying of words aloud as one reads a piece of text. Highlighting or underlining text in a rather passive and unreflective manner also can be more like a rehearsal strategy than an elaborative strategy. These rehearsal strategies are assumed to help the student attend to and select important information from lists or texts and keep this information active in working memory; however they may not reflect a very deep level of processing.

Elaboration strategies include paraphrasing or summarizing the material to be learned, creating analogies, generative note-taking, explaining the ideas in the material to be learned to someone else and question asking and answering.

Organizational strategy includes behaviors such as selecting the main idea from text, outlining the text or material to be learned, and using a variety of specific techniques for selecting and organizing the ideas in the material. Contrary to rehearsal strategies, organizational strategies have been shown to result in a deeper understanding of the material (Newton, 2000).

Most models of metacognitive control or self-regulating strategies include three general types of strategies: planning, monitoring and regulating. Planning activities include setting goals for studying, skimming a text before reading, generating questions before reading a text, and doing a task analysis of the problem. These activities seem to help the learner plan their use of cognitive strategies and also seem to activate or prime relevant aspects of prior knowledge thus making the organization and comprehension of the material much easier.

Monitoring activities include tracking of attention while reading a text or listening to a lecture, self-testing through the use of questions about the text material to check for understanding; monitoring comprehension of a lecture, and using test-taking strategies in an examination situation. In order to be self-regulating, there must be some goal or standard or criterion against which comparisons are made in order to guide the monitoring process. Metacognitive activities were seen as partly the monitoring of comprehension where students check their understanding against some self-set goal.

Regulation strategies are closely tied to monitoring strategies. As students monitor their learning and performance against some goal or criterion, this monitoring process suggests the need for a regulation process to bring behavior back in line with the goal or to come closer to the criterion. For example, as learners ask themselves questions as they read in order to monitor their comprehension, and then go back and reread a portion of the text, this rereading is a regulatory strategy. Another type of self-regulatory strategy for reading occurs when a student slows the pace of their reading when confronted with more difficult or less familiar text. During a test, skipping questions and returning to them later is another strategy that students can use to regulate their behavior. All these strategies are assumed to improve learning by helping students correct their studying behavior and repair deficits in their understanding (Newton, 2000).

2.10 Motivation in SRL

Student learning is not only influenced by cognitive processing, environmental control utilization, and metacognition, but also by motivation (Zimmerman, 2000). Self-regulated learners possess motivational beliefs that support their coordination of cognitive processing, environment control/utilization and metacognition. Motivation includes confidence in one's ability to succeed by exerting strategic effort and recognition that success often comes only after some frustration (Zimmerman, 2000). Years of success through reflective coordination of cognitive processing, environmental control utilization and metacognition have produced "appropriate self-confidence about academic abilities, which in turn motivates future academic efforts and thus self-regulated cognition is dynamically related to motivational beliefs. both fueled by such beliefs and fueling them".

Self-regulation is tied to motivation in a number of ways. If successful learning is felt to be due to self-regulation, this places success in the control of the learner. With an attribution of this kind, learners are less likely to feel helpless and to be demotivated. The self-regulated learner is likely to feel a great degree of autonomy than the externally regulated learner. There are three general types of motivational beliefs: self-efficacy beliefs, task value beliefs and goal orientations.

Zimmerman (2000) uses the construct of self-efficacy as a key personal factor in their view of SRL. According to Bandura (1986), self-efficacy refers to personal beliefs about one's capabilities to learn or perform behaviors and skillful actions at desired levels . Self- efficacy has consistently been found to be related to cognitive processing, environmental control/utilization, and metacognition as well as academic success. Effective SRL depends on holding an optimal sense of self-efficacy for learning. Students who feel efficacious about learning choose to engage in tasks, select effective strategies, expend effort, and persist when difficulties are encountered. Self-efficacy has been defined as individuals' beliefs about their performance capabilities in a particular domain. The construct of self-efficacy includes individuals' judgements about their ability to accomplish certain goals or tasks by their actions in specific situations. The findings for self-efficacy showed very positive relations between self-efficacy and self-regulated learning for both middle school and college students. Students who felt more efficacious about their ability to do well in the course were more likely to report using all three types of cognitive strategies (rehearsal, elaboration, and organizational strategies) Students high in self-efficacy were more likely to be cognitively involved in trying to learn the material in comparison to those low in efficacy, even if some of their strategies (i.e., rehearsal) were not deep level comprehension strategies. Self-efficacy also was positively related to self-regulatory strategies such as planning, monitoring, and regulating.

In achievement dynamics, there are three components of task value: the individual's perception of the importance of the task, their personal interest in the task and their perception of the utility value of the task for future goals. Task value beliefs were correlated positively with cognitive strategy use including rehearsal, elaboration, and organizational strategy. Students who reported higher levels of interest and value were more likely to report that they were using more strategies to monitor and regulate their cognition.

There are three general orientations concerning goal orientation theory: a mastery goal-orientation, an extrinsic orientation and a relative ability orientation. A mastery goal orientation refers to a concern with learning and mastering the task using self-set standards and self-improvement. An extrinsic orientation includes a focus on getting good grades and pleasing others (teachers, parents) as the main criterion for judging success. A relative ability orientation refers to a concern with comparing one's ability or performance to others and trying to better them, to do better than others on the task. In one study, consistent relations have been found between different goals and self regulation. Mastery goals were strongly positively related to the use of cognitive strategies as well as self-regulatory strategies. Mastery goals were related to actual performance in the class. Extrinsic goals were the only motivational variable that showed consistent negative relations to self-regulated learning and performance. Students concerned with being better than others did report using more cognitive and self-regulatory strategies and also performed better in class.

Pintrich (2000) has shown that motivation (i.e., intrinsic motivation and self-efficacy) has a substantial impact upon SRL adoption of a learning and mastery orientation and positive evaluations of competence lead to greater use of cognitive processing, environmental control/utilization, and metacognition. SRL, in turn, leads to higher levels of motivation.

In summary, motivation, involving intrinsic motivation and self-efficacy, has a substantial impact upon SRL, cognitive processing, environmental control/utilization, and metacognition.

2.11 SRL Strategies and Academic Achievement

Zimmerman and Martinez-Pons (1986) found after a research study that high achieving students displayed significantly greater use of all SRL strategies and significantly less use of “other” responses than the low achievement group except for self-evaluation. In addition, students’ self-report of SRL strategies had a significant positive correlation with their standardized test performance.

This finding was supported by another study by Zimmerman and Martinez-Pons (1988). High achieving students were found to use more learning strategies and were more likely to seek help from instructors compared with low achieving students. Students who need help the most were least likely to seek help. Another important finding of this study was that successful students tended to be aware of how well they had done on a test even before getting it back from the instructor indicating the importance of monitoring performance.

An important finding from Pape and Wang’s (2003) study is that it is the number of different strategies or different categories of strategies reported rather than the total number of strategies reported that was significantly related to students’ mathematics and reading achievements. This implies that with limited number of different strategies and limited number of categories of strategies available, less successful students simply cling to the same strategies available to them.

What are the processes that underlie self-regulatory knowledge? Self-regulated learning theorists view learning as a process that occurs in three major phases identified as (1) forethought, (2) performance and volitional control, and (3) self-reflection (e.g., Zimmerman, 1998). According to Zimmerman (2000), the forethought phase ‘refers to influential processes and beliefs that precede efforts to learn and set the stage for such learning’. The second phase ‘involves processes that occur during learning efforts and affect concentration and performance’.The third phase involves ‘processes that occur after learning efforts and influence a learner’s reactions to that experience’.

2.12 SRL and Problem Solving

The Principal and Standards for School Mathematics contains five content standards, which delineate important content students are to learn, and five process standards, which describe capabilities with which all students should leave from the mathematics classroom (NCTM, 2000). Among these process standards is problem solving, which defines ways of thinking and knowing, a stance toward learning, and abilities mathematics students should possess. "Students should have frequent opportunities to formulate, grapple with, and solve complex problems that require a significant amount of effort and should then be encouraged to reflect on their thinking" (p. 52). According to this standard, mathematics instruction should, for example, enable students to, "apply and adapt a variety of appropriate strategies to solve problems" and to "monitor and reflect on the process of mathematical thinking" (NCTM, 2000, p. 52). These behaviors are very similar to those discussed within SRL literature, including monitoring progress toward solutions; adjusting behavior depending on observations of progress; reading and listening carefully to ensure understanding; planning frequently; considering alternative strategies; and reflecting on one's progress(Pape and Smith, 2002).

Problem solving is perhaps the area of mathematics in which self regulation is most apparent (Mayer, 1992). Successful problem solvers are strategists in developing an understanding of a problem and forming a concrete or mental problem representation. As a student reads a problem, he or she may write down pertinent information, draw a picture, or create a table for the elements of the problem. These discrete components are brought together in a coherent mental representation of the relationships between the problem elements. Next, the student plans a solution strategy, which necessarily depends on the representation formed. Each of these phases, representation and solution, depends on specific types of knowledge structures and the coordination of these types of knowledge (Mayer, 1992).

Within the realm of mathematical problem solving, self-regulation translates into careful decoding of the problem text and analyzing the relationships between and among the problem's components to form a mental model for the problem. Given this mental representation, the problem solver chooses a mathematical algorithm, or procedure, to solve the problem. Once chosen, the individual must monitor how to carry out the algorithm toward a solution. Finally, the problem solver must check his or her solution in relation to the given problem. Each of these steps involves forethought and planning, monitoring the fidelity of the solution process, and reflecting on the problem to determine whether the representation formed is accurate and whether the solution process is successful

CHAPTER 3

METHODS OF THE PRESENT STUDY

This chapter explains the description of the overall research design, participants of the study, instruments, the treatment procedure, the variables, methods for analyzing data, treatment verification and power analysis.

3.1 Research Design

In this study, not the individuals but the groups were randomly assigned to experimental and control groups. Hence, the study was a quasi experimental design (Fraenkel & Wallen, 1996). Table 3.1 presents an outline of the research design.

Table 3.1 Research design of the study

	O (Test)	X (Treatment)	O (Test)
Experimental Group	BMAT MPST MSLQ	Questioning Problem Solving Approach	BMAT MPST MSLQ
Time Duration	One-week	10 weeks	One-week
Control Group	BMAT MPST MSLQ	Traditional Problem Solving Approach	BMAT MPST MSLQ

As seen in Table 3.1. firstly, pretests were given to both control and experimental groups. The experimental group was instructed by questioning problem solving approach. In contrast, control group was instructed traditional approach. Post tests were given to all groups after the treatment periods.

3.2 Participants of the Study

The most appropriate sampling is convenience sampling when it is really difficult to select a random sample of individuals (Fraenkel & Wallen, 1996). Considering the administrative and physical structure of the elementary education department in the university, the effort and the ongoing curriculum, it was nearly impossible to select a sample by simple random sampling. Accordingly, the subjects of the study consisted of (n=110) first grade pre-service elementary teachers of the elementary teacher education division at a public university in Central Anatolia Region during the spring semester of the 2007-2008 academic year. In this division all first grade pre-service teachers were divided into four sections. All sections were involved and formed the sample of the research. The administration of the department joined Section A and Section D into one group and Section B and Section C into another group. So not the individuals but the groups were assigned randomly as experimental and control groups. The number of students in each group with respect to gender is given in Table 3.2.

Table 3.2 The distribution of the subjects in EG and CG respect to gender

	Groups		
	EG (%)	CG (%)	Total
Female	42 (75.4)	43(79.2)	84 (77.3)
Male	12 (24.6)	14(20.8)	26 (22.7)
Total	53 (100)	57(100)	110 (100)

As can be seen in Table 3.2, a total of 57 students in the control group were instructed by traditional problem solving approach while 53 students in the experimental group were lectured by questioning problem solving approach. One instructor and 110 first grade pre-service elementary teachers were involved in this quasi-experimental study. Additionally, Table 3.2 represents the group's general characteristics with respect to gender. Within groups, it could easily be seen the distinction between the number of female and male students. This discimination is a usual picture in division of elementary teacher education.

3.3 Instruments

In order to collect data, the Basic Mathematics Achievement Test, the Mathematical Problem Solving Test, Motivated Strategies for Learning Questionnaire (MSLQ), Treatment Evaluation Form and the observation checklists were used. Additionally, interview were used to collect data three times during the treatment in this study

3.3.1 Basic Mathematics Achievement Test

The purpose of the Basic Mathematics Achievement Test was to investigate pre-service elementary education teachers' basic mathematics achievement. This test consists of 12 open-ended questions and covers the concepts of the Basic Mathematics II Course. This 12 open- ended questions were prepered to adress the learning goals specified in the Higher Education Council.

To analyze the students' answers in details and to understand their mathematical solutions and computations, open-ended questions were used. The test combines typical mathematical achievement questions and piloted with third grade pre-service elementary teachers in the same department of same University. This test was used for both pretest and posttest in this present study and is presented in Appendix C.

The test covers the following concepts: definition of an equation in algebra, equations on unknown first and second degrees, relation and function concepts and samples, graphs of functions (line, parabola, etc.), fundamental theorems on plane, points on space, line and plane, lines and angles, polygones, triangle, quadrilaterals (four sided polygones), circles, perimeter and area of planar of two dimentional objects, volume and surface area of three dimensional objects (cube, prism, cylinder, pyramid, cone, sphere, etc.). The test content and objectives were determined according to Higher Education Council.

The researcher is familiar with the concepts and has more experience about fisrt grade pre-service teachers' mathematical knowledge, their backgrounds and mathematical achievement because of having being instructed in Basic Mathematics Course until 2001. The table of specifications was formed by using Bloom's Taxonomy.

Items three through seven, were developed by a researcher, item two adapted from MoNE (2005a), item one adapted from Olkun's (2006) unpublished basic mathematics lecture notes, item twelve is an adapted Secondary Education Entrance Examination (OKS) question.

The validity of the test in terms of gathering face and content-related evidence was provided by writing on a piece of paper; the characteristics of the sample and the description of the test in terms of the objectives they intended to measure. Afterwards, Then this paper along with the instrument was given to the experts. One mathematics education professor, one associate professor, one assistant professor, two instructors two doctoral students and two graduate students from mathematics education were involved to obtain face and content validity. They judged whether the test items were appropriate to the grade level and of the measurement. The test received its final form after getting their opinions and agreements. A pilot study for this instrument was conducted with 100 third grade pre-service elementary teachers from the same department. The value of Cronbach alpha from the post implementation of the BMAT was 0.76.

To score the students' responses to each question in BMAT, the five-point rubric was used. This rubric was developed by the researcher. The highest point of 5 indicated a complete understanding of underlying mathematical concepts and procedures while the lowest point of 0 was given for irrelevant or no responses. The minimum and maximum possible scores from the test items are 0 and 60 points, respectively. To measure internal consistency reliability, an expert in the field was involved in the study. After completion of the post test the researcher and an expert graded the scores with respect to rublic and internal consistency. Correlation coefficient was calculated between the researcher scores and expert's scores 0.93.

3.3.2 Mathematical Problem Solving Test

The mathematical Problem Solving Test consisted of mathematical problems which were related with the topics of the Basic Mathematics Course II. This test consists of 17 open-ended questions and is given in Appendix B. The purpose of this test is to obtain data about pre-service teachers' mathematical problem solving performance.

In developing an items process, researcher constructed an item bank by reviewing the literature. These items were selected and adapted with respect to the first grade pre-service teachers' mathematical knowledge, backgrounds and reasoning and their cognitive level. Problems were selected to cover every concept of the Basic Mathematics Course II, (e.g., definition of an equation in algebra, equations on unknown first and second degrees, relation and function). After conducting an item pool, the selected items were re-selected again and checked by the adviser and the researcher, by considering problem type, problem originality, and the number of their solution strategy that can be considered. In this process the important criterion for selecting problems is, suitability - having at least problem solving strategy in its solution.

All items except four of them were adapted form related literature. Problem 2, 3, 13, 14 were adapted from Posamentier's (1998) book. Problem 4 and 5 were adapted from MoNE (2005a). Problem 7, 12 and 16 were adapted from Olkun's unpublished basic mathematics lecture notes. Problem 15 was an OKS question, problem 6, 8, 9 and 10 were developed by the researcher. Other problems were adapted from a variety of mathematics books and literature.

In obtaining evidence on the face and content validity of this instrument, these same mathematics educators and experts were involved, as mentioned before, for basic mathematics test face and content validity. Before the implemetation, they judged whether the problems are appropriate for grade level and measurement. They solved the problems and checked whether they are solvable by at least two different solution strategies or not. The test received its final form, with respect to their opinions. The pilot study, was conducted with third grade pre-service teachers from the same department which had similar characteristics involving socio-economic status and mathematical knowledge. The value of Cronbach alpha from the post implementation of the MPST was measured at .70.

To score the students' responses to each problem a MPST, five-point holistic grading rubric was used. This rubric was developed by Umay (2007). The researcher preferred to use holistic rubric instead of an analytic one, thus assigning a numerical score to the total solution of a problem based on criteria related to the specific thinking process. Holistic grading rubrics focus on the total solution and process, not just on the answer. The highest point of 5 indicated a complete and appropriate solution and answer while the lowest point of 0 was given for irrelevant solution or answer or no responses. The minimum and maximum possible scores from the test items are 0 and 85 points, respectively.

To measure internal consistency reliability, an expert in the field was involved in the study. After completion of the post test, the researcher and an expert graded the scores with respect to rublic and correlation coefficient was calculated between the researcher scores and expert's scores 0.92.

In this study this test was used in both experimental and control groups as pretest and post test.

3.3.3 Motivated Strategies for Learning Questionnaire (MSLQ)

This scale was originally developed by Pintrich, Smith, Garcia, and McKeachie in 1991. It is a self-report, seventh point likert-scaled instrument. It was designed to assess perceived motivation and use of learning strategies by students. In this study the Turkish version was used which was adapted by Sungur (2004). Sungur adapted MSLQ to the Turkish language to assess high school students' perceived motivation and perceived use of learning strategies. When considering the age of participants of this present study, it was deemed appropriate to use this Turkish version. This instrument is presented in Appendix A. The motivation scales divide into three subscales: value component (intrinsic and extrinsic goal orientation, task value), expectancy components (control beliefs about learning, self-efficacy), and affective components (test anxiety). The learning strategy scale is comprised of two scales, which can be distinguished as cognitive and metacognitive and research management strategies. The cognitive and metacognitive strategies are assessed by (a) rehearsal, (b) elaboration, (c) organization, (d) critical thinking and (e) metacognitive self regulation subscales. Resource management strategies include (a) time and study environment management, (b) effort management, (c) pear learning, and (d) help seeking. In total this questionnaire incorporated fifteen subscales. The Turkish version consists of 81 items, 50 of them are related with learning strategies and 31 are about motivation.

All items were scored from "not at all true of me" as 1, to "very true of me" as 7. Negatively worded items were reversed to a positive direction for scoring purposes.

For a pilot study, MSLQ was conducted with all third grade pre-service teachers in the same department of the same university before administered as pre test. Explanations of subscales were given as the following:

Intrinsic goal orientation was measured as to whether students perceive themselves participating in a task for challenge, curiosity and mastery. This subscale consisted of four positive worded items such as "In a class like this, I prefer course material that really challenges me so I can learn new things."

Extrinsic goal orientation was measured whether students purpose in a task is grades, rewards, performance, evaluation by others and competition. This subscale consisted of four positive worded items such as, "Getting a good grade in this class is the most satisfying thing for me right now. "

The task value sub-scale's purpose was to evaluate student's perception of course material with regard to interest and utility. This subscale involved six positive worded items such as, “I am very interested in the content area of this course.”

Control of learning beliefs, was assessed as to whether students believes that their efforts contribute to positive outcomes. This subscale, consisted of four positive worded items such as, “If I study in appropriate ways, then I will be able to learn the material in this course.”

Self-efficacy for learning and performance in mathematics was assessed as to whether students’ judgement on one’s ability to accomplish a learning task. This subscale consisted of eight positive worded items such as, “I am confident I can understand the basic concepts taught in this course.”

Test Anxiety subscale consisted of five positive worded items such as, “When I take tests I think of the consequences of failing.”

Learning Strategies Scales consisted of cognitive metacognitive strategies and resource management strategies. Cognitive strategies subscale consists of 19 positive worded items with four subscales. The first subscale is rehearsal which measured the use of rehearsal that emphasizes the repetition of information in a task. “When I study for or this class, I read my class notes and the course readings over and over again” could be given as a sample item form this subscale. The second subscale, elaboration, measured the use of elaboration strategies such as, paraphrasing, summarizing, organizing and note taking. This subscale involved six positive worded items such as, “I try to relate ideas in this subject to those in other courses whenever possible”.

The next subscale is organization which measured the students’ perceived use of organization strategies such as clustering, outlining, selecting the main point from the text. This subscale involved four positive items such as, “I make simple charts, diagrams, or tables to help me organize course material”

The last subscale of cognitive learning strategies is critical thinking. This strategy measures as to whether students apply previous knowledge to a new situation. A sample item is, “Whenever I read or hear an assertion or conclusion in this class, I think about possible alternatives.” The critical thinking subscale involved five positive worded items.

Metacognitive self regulation strategies involved twelve items in which 2 of them were worded negatively. This subscale measured students perceived matecognitive strategies such: as; planning, monitoring and regulating in a learning task. “When reading for this course, I make up questions to help focus my reading” and “When I become confused about something I'm reading for this class, I go back and try to figure it out” can be given as samples.

Resource management strategies involved four subscales. The first is time and study environment management. This subscale consists of eight items in which two of them are negatively worded. The items measured the students’ time management strategies and arranged an environment where they could study efficiently. “I usually study in a place where I can concentrate on my course work” and “I make good use of my study time for this course” are samples of items in this scale.

Effort regulation consisted of four items that measured students’ performance to complete the task when they encountered challenges. This scale consisted of four items such as, “I work hard to do well in this class even if I don't like what we are doing”. Two of them were negatively worded.

Peer learning items measured students’perceived strategies that collaborate with their peers in their learning process. This scale cocnsited of three positive worded items such as, “When studying for this course, I often try to explain the material to a classmate or friend”.

Help seeking included four items to measure students’ perceived strategies to identify someone from whom they can receive assistance. Two of the items were negatively worded and, “I ask the instructor to clarify concepts I don't understand well” is given as a sample item.

The reliability coefficient of all scales from the post implementation is presented in Table 3.3 below

Table 3.3 Reliability coefficients of scales on MSLQ

Scale	Number of Items	Present study	Sungur'study
Intrinsic goal orientation	4	0.72	0.73
Extrinsic goal orientation	4	0.59	0.54
Task value 4	6	0.85	0.87
Control and learning beliefs	4	0.65	0.62
Self-efficacy for learning and performance	8	0.89	0.89
Test anxiety	5	0.59	0.62
Rehersal	4	0.68	0.73
Elaboration	6	0.79	0.78
Organisation	4	0.66	0.71
Critical Thinking	5	0.79	0.81
Metacognitive self-regulation	12	0.80	0.81
Time and study environment management	8	0.70	0.73
Effort Regulation	8	0.62	0.62
Peer learning	3	0.64	0.61
Help seeking	4	0.55	0.57

According to Table 3.3, the value of Cronbach Alpha from the post implementation range is from 0.55 to 0.89. In this study MSLQ was used in both experimental and control group as pretest and post test.

3.3.4 Observation Checklists

Classroom observation checklists were developed by the researcher in order to use the/a rate for treatment verification. The items in observation checklists were facilitated to ensure that the teacher instructed problem solving only in the experimental group and the traditional method only in the control group. The items were developed with respect to the teacher's behaviors such as relation with the students, student related behaviors, physical conditions of classrooms (e.g. lightening in the class).

The treatment in experimental group was questioning problem solving approach. This approach was based on Polya’s problem solving approach and reflected social constructivism. So items were developed according to this aspects. This Observation Checklist is given in Appendix E.

There were 32 items and responses were seven points, Likert type scale. All items were scored from “bad” as 1, to “good” as 7.

Two graduate and one doctoral students were involved as independent observers in this study. One of them observed both the control group and the experimental group. Others observed seperately the experimental and control group, so two observers attended regular lessons of the experimental and control group classes. The reasearcher gave information about the treatment, process, the teacher’s role in the experiement group before the implementation. They sat at a desk in the classroom and filled the observation checklists for experiment and control group during the lesson. The items on this check list were conducted as to whether the treatment was applied as intented in both groups or not and additionaly to avoid one important internal validity; researcher bias.

3.3.5 Interviews

The general aim of these interviews is examine the fourth reserach question “How does the student’s problem-solving performance change during the study according to the Polya’s phases?”. Interview task protocols were conducted by the researcher with experimental group’s participants three times during the process.

Interview questions were structured but follow up probing questions were also used. Open-ended questions used to measure students’ performance with respect to Polya’s problem solving four-phases;

1. Understand the problem;define the problem by identifying various problem basics and how they are related,
2. Devise a plan ; examine the different elements of a problem from a variety of ways to identify a solution method that will work,
3. Carry out the plan ; carry out the chosen strategy and evaluate the accuracy through reasoning,

4. Look back; applying and reflecting on the results and consequences, asking if a different method could be applied.

Some questions of the semi-structured interview task protocol are given as follows:

"What did you do first when given the problem?" Next?

"What question is asked in the problem? What are the important facts, conditions in the problem? Do you need any information not given in the problem?

"Is there anything you don't understand about the problem? "

Have you made a plan to solve the problem, if yes, what kind of a plan?

"What strategy are you using?"

"Are you sure this is the correct answer?" Why?

"Did you check your answer?" Why?

"Do you think it is important to check your answer" Why?

"Is this problem like any other problem you have solved? How?

The think aloud interview protocol was tested with eight students. They were chosen randomly from the low, high and moderate achiever groups. Their previous year mathematics grade were used for determination of their achievement level. One expert views were taken for providing content validity.

The interview process involved the purposeful sampling of 8 students from experimental group. Eight students were selected with respect to their perivous year mathematics class. Purposeful sampling, as used in qualitative research methods, selects information rich cases for in-depth studies (Maxwell, 1996; Patton, 1990). The researcher informed the interview participants about the purpose and the content of the interview, and then the researcher asked each of the participant's permission to record all the interview session by audio recorder.

Each interview lasted approximately 30-40 minutes. During the interviews, there were some rules that the researcher had to obey and situations that the researcher provide for the participating interviewers. Firstly, the researcher informed the interview participants about the purpose and the content of the interview, and then he or she asked each of the participant's permission to record all the interview session by audio recorder. For facilitating understanding of students' thoughts, it is crucial that the participants feel comfortable and willing to give honest answers to the questions. These interviews took place in a meeting room that arranged for students' schedules. In addition, during each interview, the researcher paid careful attention to listen to the students.

The researcher conducted three interviews during the treatment with participants in the experimental group. The first was conducted during the first week of the treatment to understand their situation in the problem solving process, the second one took place in the fifth week which was the mid-term of the treatment duration and the last took place during the last week. In every interview duration students tried to solve 2 problems. These problems were selected by taking into consideration solving test sections for mathematical problems. For facilitating understanding of students thoughts, it is crucial that the participants feel comfortable and willing to give honest answers to the questions. Hence, the subjects were told that they have the freedom to express any views or concerns they had about the session during the interviews. Aside from this, during each interview, the researcher paid careful attention to listen to the students. The data were coded by two different researchers to strenghten the reliability of the qualitative analysis results.

3.3.6 Treatment Evaluation Form

This questionnaire was developed by the researcher to learn the pre-service teachers' general opinions about the treatment. It consisted of four open-ended questions. The questionnaire was applied to only experimental group in the last week of the session. According to responses, pre-service teachers' opinions about the problems that were solved in the lessons, implementation of the treatment, negativities of treatment in application, positive and negative aspects of treatment in application classroom were defined. The general aim of using this form is to define and understand students' perspective about the treatment during the semester. One expert views were taken to provide content validity. The data were coded by two different researchers to strenghten the reliability of the qualitative analysis results. This questionnaire is given in Appendix F.

3.4 Procedure

The aims of this study were to investigate the effect of the questioning problem solving approach on first grade pre-service teachers' basic mathematics achievement, problem-solving performance, perceived motivation and perceived use of learning strategies compared to the traditional teaching. To receive the students' views related to the effects of the treatment on their learning and to understand whether problem solving affected the students' problem solving performance or not.

The study was conducted in Basic Mathematics Course II, applied in Elementary Teacher education division. This was a quasi-experimental study, in which two different problem solving approach, the questioning problem solving approach and traditional problem solving approach were compared. In Table 3.4 the overall process throughout the study is presented.

Table 3.4 The outline of this study

Process	Period
Determination of key words	2006
Reviewing related literature	Since 2006
Development of instruments	January 2007- January 2008
Preparation and development of lesson plans	January 2007- January 2008
Piloting of instruments and lesson plans	February 2008-June 2009
Application of pretests	February 2008
Implementation of the treatment	February 2008-June 2009
Application of post tests	June 2008
Analysing the data and writing the dissertation	Since June 2008

In the 2006-2007 academic year, this study commenced with the determination of these key words: “Self -regulation and mathematical problem solving” with a detailed literature review relating to mathematics education and educational science sources. After a detailed examination of the literature and reading all the obtained documents, the research problems were narrowed and specified. This phase was a continuing and developing process. During the study the researcher searched the Dissertation Abstracts International, the Social Science Citation Index, the Educational Resources Information Center (ERIC), Internet, the Higher Education Council and Periodicals in METU library, Bilkent University, Hacettepe University and TUBİTAK Ulakbim. In this phase, undergraduate elementary teacher education students were determined as the possible sample of the main study. Then the instructional design of the study was developed. In the curriculum of the elementary teacher education program, only two mathematics courses are involved which are Basic Mathematics I and II. Thus, Basic Mathematics II was determined to implicate the treatment. For the task of the study, the researcher did not find a valid and a standardized instrument for the first grade pre-service teachers’ basic mathematics achievement and problem solving performance, so after determining the instruction and research questions, the following steps were taken relating to the development and adaptation of the instruments.

In developing and adopting the tests process firstly, the Basic Mathematics Achievement Test was prepared after a lengthly search of the literature. Details related to the development of this instrument are clarified in Section 3.3.2

The second step in developing and adopting the instrument is the preparation of the problem solving performance test. The researcher formed a wide problem type item pool with respect to considering the participants mathematical knowledge, their cognitive and metacognitive level. All of the problems are related to the contents of the Basic Mathematics Course II. Those problems were selected with the help of the advisor to the researcher with respect to considering students’s mathematical knowledge, quality of problems and problem types.

Since the main thesis of the study was the process of problem solving, first, the problem solving strategies were explored through the resources in domestic and foreign literatures and the definitions of the process of problem solving in textbooks. Differences were found in different resources on the meaning of strategy. It was finally decided to teach the seven strategies (working backwards, finding a pattern, adopting a different point of view, accounting for all possibilities, logical reasoning, making a drawing (visual representation), writing an equation) selected by taking into consideration the participants' ages, mathematical skill and the contents of the Basic Mathematics II Course.

All the other sub steps of the development of this instrument is explained in detail in Section 3.3.3. The last step was formation of MSLQ. This test was adapted and originally translated by Sungur in 2004. Sungur (2004) used MSLQ to measure nineth grade high school students' perceived biological motivation and their perceived use of learning strateğies in a biology course. Thus, it was revised in order to use it for a mathematics course.

All of these instruments were piloted with third grade pre-service teachers in the same department of same university in the first semester of the 2007-2008 academic year. According to the results of the pilot study and related literature, all of these instruments were formed and validated. The final form of these tests were administered as pre- and post test to both the EG and the CG.

The development of the lesson plans was the last step before the treatment period. The resarcher and also the instructer taught Basic Mathematics Courses until 2001, so both have the experince in first grade pre-service teachers' characteristics, their content and procedural knowledge and classroom setting. Before developing lesson plans, several mathematics books, dissertations and lesson notes of different authors were reviewed and problems were examined. For the instructional unit addressed in this dissertation, most of the problems were adapted from different sources or developed by the researcher. Adaptations were done on the problems, including the appropriateness of the context for the participants. The instructional unit was controlled in order to assure the mathematical correctness of the problems and appropriateness to the concepts by the researcher's advisor.

Lesson plans were prepared to facilitate the process of treatment instruction teaching in experimental classes. They were used to make a more structured treatment, to prevent consuming time and to apply it easily in experimental classes. In order to develop the lesson plans, a list of criteria for problem solving was developed after reviewing the literature.

The researcher prepared 2 or 3 problems for every lesson that can be solved by using different strategies related to the content of the particular lesson. The lessons plans were prepared by taking into account the questioning problem solving by the researcher, and the lesson plan got its last form after the pilot study. Lesson plans were piloted on third grade elementary teacher education students of same university during Teaching Mathematics II Course before the implementation. The purpose of piloting lesson plans is to test their appropriateness for the topics, applicability in classroom settings, and attractiveness to the students. Furthermore, this pilot study also provided the researcher experience about method.

Approval for this study was requested from management of the university in January 2007 and obtained in March. This approval included the permission of conducting a study in the division of elementary teacher education in the faculty of education. Getting this approval enables the researcher to conduct and apply the study. There were two convenient groups, therefore the researcher randomly selected one group of elementary teacher education division and assigned it as an experimental group. One of the groups was designated as the experimental while the other one served as the control group.

The next step was the application of pretests. In the second week of the spring semester of the 2007-2008 academic year, the researcher applied all instruments as pretests to calculate the scores gained by the students for each group. Students took the instruments in their regular classroom. First, BMAT was administered and the time allotted for this instrument was 45 minutes. After a break of 10 minutes, the MPST was given and administered in 60 minutes. During the administration of the instruments, students were encouraged to ask questions considering the fact that some students could not read the problems and questions, but no feedback or explanations were given regarding the accuracy of their solution. The MSLQ was administered to students as pre-test in a short period of time on another day of the same week, in order not to make students bored with long administration time. During the week the researcher conducted the first and? last follow-up interviews with 8 selected students in order to determine the students' problem solving performance. For this purpose, semi-structured protocol for the interviews was used.

Before the implementation, it became necessary to make students familiar with qustioning problem solving so that they were ready for the actual implementation. Definition of a problem, the strategies of solutions (eg; working backwards, making a pattern, using a table) and the phases of problem solving were explained to the students in the first week's lesson hours. Thus, they received information about the definition of the problem, type of solution strategy and problem solving before implementation.

After the administration of instruments, during the third week of the spring semester the treatment applications were started. The experimental group students were instructed on using QPST whereas the control group took TPSA as a treatment. The lessons were conducted by using the lesson plans developed by considering problem solving.

The equality of two groups defined above was controlled statistically by comparing their, the pretest scores of the Basic Achievement Test (PreBMAT), the Mathematical Problem Solving Performance Test (PreMPST) and pre test scores of all sub- scales of the MSLQ such as PreIGO and PreEGO.

The course instructor was the same person for both experimental and control group. Both groups were instructed by the researcher. To control researcher bias and to check the flow of the lesson in terms of the objectives, two graduate students observed both groups during the implementation period. All first grade pre-service teachers were taught the same concepts of basic mathematics course according to the course outline during the same amount of time. The Basic Mathematics II course is offered as a compulsory course to elementary teacher education students in the first year of the curricula of the program. In this course, students learn the basic concepts of mathematics in terms of both theoretical and practical base. The course length was 2 hours theoretical, totaling 2 hours per week throughout the semester/course.

The content was not changed for the two groups. The main difference between the two groups was the implemantation of the treatment during the semester. The detailed explanation of the treatment is mentioned in Section 3.8. In the fifth week of the treatment duration the second interview task took place . After 10 weeks of period, the instructor conducted BMAT, MPST and MSLQ as post tests in the experimental and control groups. The method of administering all the instruments were the same as described in the pretests.

After collecting and analyzing the pretest and post test data, the researcher conducted the last follow-up interviews with the same selected students in an effort to have an in-depth understanding of their utilization of problem solving process at the end of the treatment. For this purpose the same semi structured protocol for the interviews was used as before.

The last phase was entering the data, analyzing them and writing the overall dissertation in the light of qualitative and quantitave outputs. The scores gained were analyzed to measure the effectiveness of the treatment.

3.5.Lesson Plans

The key points and basic elements of preparing lesson plans were, problem type, students' role and instructor's role in the problem solving process. All these key words from the literature, the large but limited course description prepared by the Higher Education Council, specific and general objectives were taken into consideration in order to develop the lesson plans. Moreover, researcher's past studies in the field and experiences in teaching Basic Mathematics Course were also reflected in the development of the lesson plans. All these key words from the literature, the course description by Higher Education Council and specific and general objectives existing in the mathematics books, were taken into consideration in order to develop the lesson plans. The concepts of this course are:

- Definition of an equation in algebra , equations in unknown first and second degree

- relation and function concepts and their samples
- Graphs of functions (line, parabola, etc.)
- Fundamental theorems on plane, points on space, line and plane
- Lines and angles
- Polygones
- Triangles
- Quadrilaterals (four sided polygones)
- Circles
- Perimeter and area of planar of two dimentional objects
- Volume and surface area of three dimensional objects (cube, prism, cylinder, pyramid, cone, sphere, etc.)

The learning objectives of the course were provided by the Higher Education Council, as indicated below. At the end of the semester, after completing this course, the student would be able to:

- Constitute the basic structure of first and second degree equations, solve and comprehend these equations
- Define and comprehend the concept of relations and functions.
- Gain the knowledge and describe theoretical fundamentals of basic geometry, carry out and apply procedures related to theorems, lemmas and preparations.
- Conceptualize triangle, polynomias, quadrilaterals, circles and their properties.
- Carry out the applications of theoretical properties of these geometric figures on plane and apply them to exercise and problems.
- Describe properties of two dimensional and three dimensional objects
- Solve related problems and perform calculations

Lesson plans were designed to cover course objectives and problem solving goals that apply to this study. In writing lesson plans, the instruction was designed to cover the goals for problem solving in order to:

- Develop students problem solving skills
    1. Understand and formulate the question in the problem
    2. Understand the conditions and the variables in the problem
    3. Select and find the data needed to solve the problem
    4. Formulate the sub problems and select an appropriate solution strategy to pursue
    5. Correct and implement the solution strategy and attain the sub goals
    6. Give an answer in terms of the data in the problem
    7. Evaluate the reasonableness of the answer
- Develop students abilities to select and use problem solving strategies

Make/use drawing, use estimation, and work backward, consider extreme case, accounting all possibilities, finding a pattern

- Develop students to use related knowledge
- Develop students abilities to monitor and evaluate their thinking and progress while solving problems
- Develop students abilities to find correct answers to a variety of problems

Finally, the researcher shaped and blended all these assets and developed the lesson plans.

A sample problem solving process is presented below. The problem was prepared in line with the following objectives.

“Objectives; Investigating if a given relation is a function or not and being able to apply the definition of function”.

Problem: The decision taken by a university management about offering new courses is as follows:

If the number of students is less than 10 the course will not be offered; if it is between 10-20 only one section will be offered; if it is between 21-40 two sections will be offered; if it is between 41-60 three sections will be offered”. According to this, is the relation between the number of students and the number of groups a function? Explain with reasons.

The topic of functions is one of the basic topics that the students have learned in high school. Moreover, in the previous class, the students were reminded of the essentials of functions, and the conditions necessary for a relation to be a function were discussed. The class starts with the distribution of the work sheets on which this problem is written. The problem is read loudly and the students are given seven minutes to solve the problem individually. Within this time interval, the students deal with the problem individually. The teacher walks around the classroom and poses questions such as “Are there any points in the problem that are not clear?”, “Did everyone understand the problem?”. Meanwhile, the teacher provides explanatory information about the problem. After the 7 minutes, the students, if they still need, can benefit from their classmates, the teacher or the clue cards that the teacher has prepared before. This process lasts between 5-7 minutes. The students are informed that they can walk around the classroom during this process. The conditions for a relation to be a function are written on the clue cards as short reminders. In this process, the teacher walks around the classroom, talks to students and determines the students who solved the problem. If there are students who solved the problem, the teacher asks if they are sure about their ways of solution and the result, and orients them to find alternative ways of solution. After the end of this process, discussion starts.

The teacher encourages the students who solved the problem in different ways to present their solutions. The students who used different strategies present their strategies to the class. The class discusses the different ways of solution. The different solution strategies for this problem are drawing table, drawing graph, constituting equation and reasoning. The important point in this problem is to follow these strategies through using the definition of function. The definition of function as it was taught in the class is as follows:

“Let X and Y be two sets and let f be a relation from X to Y. If each element of f X is associated with one and only one element of Y, then the f relation is a function”.

One of the ways of solution that the teacher has determined before is drawing table. The data can be written in the form of table in order to see the problem more clearly. Through this strategy, the domain and the image set can be seen easier and more clearly.

Table 3.5. Domain and range of function

Domain (the number of students)	Range (The number of sections)
Less than 10	The course is not offered
10-20	1
21-40	2
41-60	3
61-90	4

Another way of solution is that a discrete-continuous graph is obtained from the given information. The interpretation of this graph shows that the relation is a function. What is expected from the students is to transform the data into a table or a graph, and then, to see that the relation is a function through the definition of function. Most of the students analyzed the relation by drawing a Venn diagram, and drawing arrows to the number of students and the number of sections, and matching one-to-one. The number of students who departed from the definition of function by drawing graph and reasoning was lesser. The problem solving process finishes with the students' discussion. The problems used in the lessons were given in Appendix G

3.6 Treatment

The Experimental Group was instructed with the problem solving instructional method while the Control Group was instructed with the traditional method. These treatments are explained in this section.

3.6.1 Treatment in Experimental Group

The study was conducted in Basic Mathematics II course throughout the semester. The Basic Mathematics II courses take place in the curriculum of the primary education division.

The rationale of the study was basically Polya's problem solving approach. First, the student must read and think about the problem. He or she must carefully identify what information is given and what is to be found. Excess information is eliminated. In this phase the teacher should ask questions such as: "What is the unknown? What are the data? What is the condition?". Next, the student decides upon a plan. A strategy is suggested to be used to solve the problem. Teacher should ask questions such as, "*Do you know a related problem?"* and should give advice as: "If you cannot solve the proposed problem try to restart to solve the problem". In the third stage, the student applies the strategy that was selected and tries to solve the problem, so as to arrive at the correct answer. In the fourth and final step, the student looks back at his or her solution and answer to make certain that his or her work is correct. In the last step the teacher should ask certain questions such as: "Can you check the result? Can you check the argument?"

The social constructivist model was taken as the basis when determining the classroom discussions. More over, the relevant problems, or the use of a problem solving strategy in a subject, were covered in the classes following the experimental study. Since, the effect of teaching problem solving appears more clearly in due course (Cai, 2003).

The implementation of treatment was started by distributing a worksheet to the students. All the problems were designed on this worksheet where the students were expected to solve problems.

The students were given some time to read and to understand the problem. They were usually given about ten to fifteen minutes to solve the problem on their own. The duration of this time period may be set by the teacher according to the type of the problem. Every lesson instructor gave a time duration to solve the problem. Every student was responsible in dealing with the problem individually. While the students worked on the problem, the teacher controlled the whole class, moved around the classroom to observe their work, gave some clues, asked some questions, explained the problem and guided the students if the problem was not understood by the students, made suggestions or gave individual help to students who had difficulty approaching the problem during this time duration.

On the basis of the observations of the student's work on the problem, the teacher carefully called on students, asking them to present their solution method on the board. The order of selecting students was important for both encouraging those students who used naive methods and highlighting the student's ideas in relation to the mathematical connection among the methods that would be discussed. The teacher noted the students who had good ideas, with the intention of calling them in certain order during the subsequent whole class discussion. This time period was 5-7 minutes according to the students' behavior in class. The teachers asked their students to find an alternative or second solution strategy if they found one and to check their solution. Subsequently, the teachers encouraged their students to work with classmates in pairs or in small groups or by themselves. They could use hint cards if they preferred. They were free to ask questions, use hint cards and take some clues. They could talk, walk in the classroom and discuss with other students if they wanted to during this time.

The idea here is to help students make their thoughts visible by encouraging them to talk and write about the processes they use to solve problems (Buschman, 2003).

After working with problems during this duration, the teacher encouraged the students who had arrived at a solution to find an alternative method for solving the problem. Students who solved the problem by using different strategies and different computation method were asked to come to the board and encouraged to show and explain their work. All different solution strategies were recorded on the board to make a comparison. Every different solution could be discussed and students could easily see the other student's different strategies. Presenting an idea, even a wrong one, was strongly encouraged and praised by the instructor. As individual students presented their methods, the class as a whole compared several solution methods with the same correct answer.

The idea here is for the class to solve problems together with the teacher serving as moderator, one that raises important questions and keeps things on track. The teacher is not to generate solutions but rather to help the students make te best of the resources they have.

The teacher asked the classroom questions like: “Does anyone have any suggestions? Any others? What made you think of that? What makes you think it’s a better alternative?

In this aspect, the teacher orchestrated the discourse so that students were functioned in an intellectual community. Finally, after discussion if no student used a specific anticipated method, the teacher may proceed with only those that were not brought up. The errors, questions or unclear parts were taken into account by the teacher to make it easy for students’ inference. Finally, the teacher reviewed and summed up the lesson and if necessary, and if time allowed, pose an exercise or an extension task that applies to what the students had just learned from the lesson. Multiple solutions to a single problem in a whole class instructional mode were used in the discussions. The lessons were continued by giving all extra theoretical information related to the content that has to be covered throughout the course.

In this present study, questioning problem-solving is applied to give students the opportunities to consistently engage in problem solving, discuss their solution strategies and build on their own informal strategies for solving problems. The teacher’s role was to create and maintain classroom environment, encourage to explore, take risks and share failure. The teacher can ensure that they help all children with problem solving, including the children’s special needs, by managing their time appropriately, managing the class routines and managing student needs by using compensatory strategies to adjust instructions to the needs of individual students (Rey et al, 2007).

In supportive learning environments students develop confidence in their abilities and explore problems (NCTM, 2000).

The lesson periods were 45 minutes for both groups. During this period two graduate students participated in the study. They observed classrooms, and students to fill the treatment verification observation check lists. The results of these observation checklists are given in Section 4.3

3.6.2. Treatment in Control Group

The control group students were instructed Basic Mathematics II course with the traditional problem solving approach. The majority of the classroom environment developed around the teacher is teacher-centered or teacher supplying information approach. Instructions covered all the same content in the control group. Moreover, same problems were solved without discussion, making comparisons. It is teacher-centered problem solving. Teaching problem solving relies on teacher's solution and explanation.

The teacher provided an explanation to the solutions. The teacher's responsibility was to offer students clear explanations and instructional objectives within a classroom.

The students in this group were passive receivers and listeners. They were listening to the teacher, taking notes on what the teacher wrote and explained on the blackboard and solving the problems and exercise on what the teacher asked. They worked individually in their own places. Rarely, did the volunteer students solved the problems on the blackboard, asked questions and participated in lessons. Teaching problem solving strategies relied on teacher explanation and textbooks.

Sometimes students tried to solve the problems but mostly the teacher solved it by her solution strategy. Thus, students neither discussed different solutions nor live the process of problem solving. The teacher allowed students to write solutions on their notebooks. The students' roles in this group are mostly passive. They were listening to the teacher, recording what the teacher wrote on the blackboard and solving the questions the teacher asked

A general comparison of the Experimental Group and Control Group in terms of physical environments, teacher's and student's role, student interaction is given in Table 3.5

Table 3.6 Comparison of the experimental and control groups

Experimental Group	Control Group
Lesson took place in a regular classroom environment Researcher is the instructor	Lessons took place in a regular classroom environment Researcher is the instructor
Teacher was the guide and facilitator to encourage students to solve the problem, make a comparison and discuss	Teacher was the leader and the role is an information giver
Students are active learners in the problem solving process. Their roles are: solving the problems by using their resources, discussing, arguing, and expressing their solutions	Students are passive learners and listeners in problem solving Their roles are; listing to the teacher, note taking the solution or rarely solving the problem by themselves
Students could work with their peers if they want	Students work alone

3.7 Treatment Verification

Throughout the study, both the experimental and control groups were observed as to whether the instructor followed the experimental and control protocols. Two observers participated in this process of study. An observation checklist was used during observations in the classroom. They were given the checklists to determine the degree to which the instructor implemented the treatment in experimental group and the absence of the problem solving approach in the control group. This checklist included 32 items about classroom, environment, student reactions and teacher behavior during instructions for comparing classroom conditions for each group. The observation checklist can be found in Appendix G.

The researcher calculated the correlations between ratings of each observer for these 40 items for experimental group as 0.884. This rating coefficients between two observers are high and significant. The correlation coefficients were calculated by Pearson correlation. By same way, correlation coefficient between two observers for the CG was found 0.927.

In observation checklist first 21 items are related specifically with the problem solving . Other items are not mainly related with the method. All items were scored from “bad ” as 1 , to “good ” as 7 and “0” means not applied in the lesson.

In Table 3.7. The means and the standard deviations of each item of the observation checklist for both the EG and CG are presented.

Table 3.7 Results of classroom observation checklist

Item number	EG		CG	
	Mean	SD	Mean	SD
1	7.0	0.0	0.0	0.0
2	7.0	0.0	1.0	1.0
3	7.0	0.0	0.0	0.0
4	7.0	0.0	0.0	0.0
5	6.7	0.7	0.0	0.0
6	6.6	0.8	6.0	0.5
7	7.0	0.0	0.0	0.0
8	5.8	1.3	0.0	0.0
9	2.4	0.7	5.7	2.1
10	7.0	0.0	0.0	0.0
11	7.0	0.0	0.0	0.0
12	6.0	1.3	0.0	0.0
13	6.8	0.4	0.0	0.0
14	6.8	0.4	0.9	0.3
15	6.2	0.9	0.0	0.0
16	5.4	1.0	0.0	0.0
17	6.6	0.8	0.4	0.5
18	7.0	0.0	4.0	2.5
19	7.0	0.0	7.0	0.0
20	6.1	1.2	3.0	1.0
21	5.2	0.4	1.0	1.0
22	7.0	0.0	6.5	0.5
23	7.0	0.0	7.0	0.0
24	6.1	0.9	4.3	0.5
25	6.6	0.7	5.5	1.0
26	5.2	1.2	5.6	1.2
27	5.6	0.5	6.0	1.1
28	6.6	0.5	6.9	0.3
29	6.7	0.5	7.0	0.0
30	7.0	0.0	7.0	0.0
31	7.0	0.0	7.0	0.0
32	7.0	0.0	5.7	1.0

As seen in Table 3.7, it can infered with the observed means of some items that lessons in the EG were implemented according to the questioning problem solving. In order to determine whether the observed mean differences between groups are statistically significant or not a non-parametric test, Mann Whitney U was used. Results of this test indicated that the items between 1 to 18 except item 6; 20 and 21 specific to the experimental method were statistically significant. The other items were related with instructors' behaviour, students' behaviour, and the physical properties of the classes were also found as the same (not significant differences). Thus, treatment verification was supported.

3.8 Variables

Eighteen dependent variables and one independent variable were considered in this study.

3.8.1 Independent Variables

Different problem solving approach, or namely group factor, is the independent variable of the study.

3.8.2 Dependent Variables

The dependent variables in this study are pre-service teachers' basic mathematics achievement, their mathematical problem-solving performance, their percieved motivation; intrinsic and extrinsic goal orientation, task value, control of learning beliefs, self-efficacy for learning and performance, test anxiety and their perceived use of learning strategies, which were: rehearsal**,** elaboration, organization, critical thinking, metacognitive self regulation, time and study environment, effort regulation, peer learning, and help seeking. The raw scores to measure these variables are obtained from the Basic Mathematical Achievement Test, the Mathematical Problem-Solving Performence Test and the Motivational Strategies for Learning Questionnaire. Thus, there were 17 dependent variables in the present study. Table 3.8 shows a brief summary of all the variables of this study.

Table 3.8 Variables of the study

Variables	Type	Nature	Measured By
Methods of teaching	Independent	Categorical	Questioning problem solving approach (1) Traditional problem solving approach (0)
Achievement	Dependent	Continuous	Basic Mathematics Achievement Test
Problem Solving Performance	Dependent	Continuous	Mathematical Problem Solving
Intrinsic goal orientation	Dependent	Continuous	Motivation scale in MSLQ
Extrinsic goal orientation	Dependent	Continuous	Motivation scale in MSLQ
Task value	Dependent	Continuous	Motivation scale in MSLQ
Control of learning beliefs	Dependent	Continuous	Motivation scale in MSLQ
Self-efficacy for learning and performance	Dependent	Continuous	Motivation scale in MSLQ
Test anxiety	Dependent	Continuous	Motivation scale in MSLQ
Rehearsal	Dependent	Continuous	Learning strategies Scale in MSLQ
Elaboration	Dependent	Continuous	Learning strategies Scale in MSLQ
Organization	Dependent	Continuous	Learning strategies Scale in MSLQ
Critical Thinking	Dependent	Continuous	Learning strategies Scale in MSLQ
Metacognition self regulation	Dependent	Continuous	Learning strategies Scale in MSLQ

Table 3.8 (continued)

Time and study environment management	Dependent	Continuous	Learning strategies Scale in MSLQ
Effort regulation	Dependent	Continuous	Learning strategies Scale in MSLQ
Peer learning	Dependent	Continuous	Learning strategies Scale in MSLQ
Help- seeking	Dependent	Continuous	Learning strategies Scale in MSLQ

3.8.3 Covariates

For the first research question, pre-service teachers' pretest scores on the Basic Mathematics Achievement Test (PreBMAT), Mathematical Problem-Solving Performance Test (PreMPST) were considered as covariates. Pre-service teachers' pretest scores on the sub-scales of Motivation scales as: intrinsic goal orientation (PreIGO), extrinsic goal orientation (PreEGO), task value (PreTV), control of learning beliefs (PreCOLB), self-efficacy for learning and performance (PreSELP), test anxiety (PreTA) were also considered as covariates for second research question. Lastly for the third research question; pre-service teachers' pretest scores on the sub-scales of learning strategies scales as; rehearsal (PreREH)**,** elaboration, (PreELA), organization (PreORG), critical thinking (PreCT), metacognitive self regulation (PreMETA), time and study environment (PreTSEM), effort regulation (PREER), peer learning (PrePL), help seeking (PreHS) were considered as covariates of this study. Therefore, totally there were 17 covariates variables used in the present study

Since the number of variables is high for the purpose of simplicity in the current study, names of the variables were frequently mentioned as the dependent variables and covariates by using symbols.

3.9 Analysis of Data

In order to find the answers to research questions both quantitative and qualitative analyses of data were used in this study.

3.9.1 Quantitative Data Analysis

The Quantitative data gathered through BMAT, MPST and MSLQ were analyzed by using Statistical Package for Social Sciences 11.0.

The researcher made missing data analysis and data cleaning process were done before starting descriptive and inferential statistics

3.9.1.1 Descriptive Statistics

The mean, median, mode, standard deviation, kurtosis and skewness of the variables, various histograms and graphs were used for both control and the experimental groups. The explanations of descriptive statistics for both groups relating to measuring tools and treatment were presented in section 4.1

3.9.1.2 Inferential Statistics

Multivariate analysis of covariance (MANCOVA) was used to test the null hypothesis of this research. The MANCOVA is a powerful statistical technique that measures the effect of independent variable(s) on more than one dependent variable. This statistical analysis was based on the multivariate general linear model, which is a generalization of the univariate general linear model, but includes more than one dependent variable and covariate(s).

Since this research comprised of multiple independent, dependent variables and covariates this inferential statistical analysis was used.

With the aim of answering the first three research questions, three seperate MANCOVA model were employed. The first MANCOVA model, was used to compare the mean scores of the control and the experimental group's pre-service teachers on basic mathematics achivement and problem solving performance while controlling the differences between groups for gender, previous year mathematics grade, the PREBMAT and the PREPSPT. The statistical model variable entry order used for this MANCOVA model is summarized in Table 3.9.

Table 3.9 The variable-set composition and statistical model entry order for the MANCOVA used for the comparing PostBMAT and PostMPST

Variable set	Entry order	Variable name
A (covariates)	1st	X1=PreBMAT X2=PreMPST
B (group membership)	2nd	X3=Groups
C (covariates*group interaction)	3rd	X4=X1*X3 X5=X2*X3 X6=X3*X3 X7=X4*X3
D (dependent variables)		Y1=PostBMAT Y2=PostMPST

Covariates were entered first, group membership the second and covariate*group interactions were entered as at third in the MANCOVA model. As the MANCOVA results only show significant differences between groups on the collective dependent variables, follow-up analyses of variance (ANCOVA) were used to understand the main effect of questioning problem solving approach on each dependent variable. All the analysis is given and explained in Section 4.2.

The second MANCOVA Model was employed to compare the mean scores of the control and the experimental group's pre-service teachers on IGO, EGO, TV, COLP, SELP and TA while controlling the differences between groups for gender, the PreIGO, the PreEGO, the PreTV, the PreCOLB, the PreSELP and the PreTA. The variables and variable entry order used for this MANCOVA model is presented in Table 3.10.

Table 3.10 The variable-set composition and statistical model entry order for the MANCOVA used for the comparing posttest scores of IGO,EGO,TV,COLB,SELP and TA

Variable set	Entry order	Variable name
A (covariates)	1st	X1=PreIGO X2=PreEGO X3=PreTV X4=PreCOLB X5=PreSELP X6=PreTA
B (group membership)	2nd	X7=Groups
C (covariates*group interaction)	3rd	X8=X1*X7 X9=X2*X7 X10=X3*X7 X11=X4*X7 X12=X5*X7 X13=X6*X7 X14=X7*X7
D (dependent variables)		Y1=PostIGO Y2=PostEGO Y3=PostTV Y4=PostCOLB Y5=PostSELP Y6=PostTA

In order to compare the mean scores of the control and the experimental group's students on REH, ELA, ORG, CT, META, TSEM, EF, PL and HS while at the same time controlling the differences between groups for gender, the PreREH, the PreELA, the PreORG, the PreCT, the PreMESR, the PreTSEM, the PreER, the PrePL and the PreHS the last MANCOVA model was employed. The variables and variable entry order for this MANCOVA model is given in Table 3.11.

Table 3.11 The variable-set composition and statistical model entry order for the MANCOVA used for the comparing posttest scores of REH, ELA, ORG, CT, META, TSEM, ER, PL and HS

Variable set	Entry order	Variable name
A (covariates)	1st	X1=PreREH X2=PreELA X3=PreORG X4=PreCT X5=PreMETA X6=PreTSEM X7=PreER X8=PrePL X9=PreHS
B (group membership)	2nd	X10=Group
C (covariates*group interaction)	3rd	X11=X1*X10 X12=X2*X10 X13=X3* X10 X14=X4*X10 X15=X5*X10 X16=X6*X10 X17=X7*X10 X18=X8*10 X19=X9*X10 X20=X10*X10
D (dependent variables)		Y1=PostREH Y2=PostELA Y3=PostORG Y4=PostCT Y5=PostMETA Y6=PostTSEM Y7=PostER Y8=PostPL Y9=PostHS

3.9.2 Qualitative Data Analysis

Qualitative data obtained from interviews and the Treatment Evaluation Form. Firstly, the responses from participants in interviews were transcribed, then demanding Polya's problem solving phases, data were coded as existance or non existance skills of understanding, making a plan, applying a plan and checking the solution. For other qualitative data obtained from Treatment Evaluation Form were read carefully to identify the common responses of the students to find the answer of the last research question. The results of the Qualitative Data is given and explained in Section 4.

3.10 Power Analysis

Before the study, determination of the population effect size (ES) process was conducted in the power analysis. Considering the results obtained from the previous related studies, a medium effect size in the study will have had a practical significance. Hence before the study, effect size was set to medium effect size of 0.15 (Cohen & Cohen, 1983, p.161). The significance level and the power of the study was set to .05 and .80 respectively because they were the most accepted values in educational studies. In other words, a Type I hypothesis-wise error rate (the probability of rejecting a true null hypothesis) of .05 and a Type II hypothesis-wise error rate (the probability of failing to reject a false null hypothesis) of .20 was set a priori to hypothesis testing. Sample size was calculated for first second and third analysis by using number of covariates in the model respectively; 56, 60 and 63. Since the sample size of the study was 110 and it was more than the calculated sample size, therefore the statistical power of the study was naturally greater than .80.

CHAPTER 4

RESULTS

In this chapter, the results of this study are divided into four sections. Firstly the descriptive statistics related to the comparison of groups with respect to pre-tests and post-tests scores. The second section deals with the inferential statistical data produced and the fifth section presents findings of the research questions. Finally, the last section summarizes the findings of the study.

4.1 Descriptive Statistics

Descriptive statistics collected on the data to identify means, standard deviations, kurtosis, skewness, minimum and maximum scores for the groups were summarized for pre and post test scores.

4.1.1 Descriptive Statistics of the BMAT and MPST

Descriptive statistics related with the pre and post test scores of BMAT and MPST for the EG and the CG were given in Table 4.1.

Table 4.1 Descriptive statistics related with the pre and post test scores of BMAT and MPST for the EG and the CG

Variables	Mean	SD	Skew.	Kurt.	Min.	Max.
PreBMAT	21.24	6.93	-0.67	1.67	0	37
PostBMAT	37.37	8.84	-0.66	1.6	8	57
PreMPST	31.49	11.61	-0.70	0.23	5	52
PostMPST	51.71	11.73	-0.65	2.15	10	73
PreBMAT	24.77	7.24	-0.66	0.61	6	40
PostBMAT	34.16	9.11	-1.16	1.29	8	45
PreMPST	22.82	9.58	0.16	0.64	0	51
PostMPST	36.82	11.10	-0.01	0.12	10	61

As it is seen in this table, before the treatment the experiment group mean scores on PREBMAT was lower than the control group mean score. An increase in mean scores was observed for both groups. BMAT scores for EG, increased from 21.24 to 37.37 and MPST increased from 31.49 to 51.71. Before treatment EG students' BMAT score were lower than CG students', but EG students' MPST scores were higher than CG students' scores. Both groups BMAT and MPST scores increased after treatment. Skewness and kurtosis values are in range between -2 and +2, except kurtosis values of the PostMPST, but it is very small violation. The gain scores with respect to group membership are given in Table 4.2.

Table 4.2 Gain scores in the BMAT and MPST with respect to group membership

Test	Group	Gain Score	Skewness	Kurtosis
BMAT	EC	15.86	0.552	0.362
	CC	9.38	-0.839	1.65
MPST	EC	20.22	0.141	-0.493
	CC	14.00	0.147	0.169

From Table 4.2, it can be said, the most increase in mean scores with respect to the both BMAT and MPST is observed in the experimental group. Preservice teachers in the experimental groups have higher gain scores than the control group's participants with regard to the BMAT and MPST.

Table 4.1 and Table 4.2 shows the skewness and kurtosis values for pretest, posttest, and gain scores for the BMAT and MPST scores. These values changes between -2 and +2, indicating that the distribution of pretest, posttest, and gain scores of both tests were normally distributed (George & Mallery, 2003).

4.1.2 Descriptive Statistics of the Motivation Scale

Descriptive statistics related with the pre and post test scores of IGO, EGO, TV, COLB, SELB and TA for the EG and the CG were given in Table 4.3.

Table 4.3 Descriptive statistics related with the pre and post test scores of IGO, EGO,TV, COLB, SELB, TA for the EG

Variables	Mean	SD	Skewness	Kurtosis	Min.	Max.
PreIGO	19.20	4.30	-0.193	-0.765	11	27
PostIGO	19.16	5.04	0.183	-0.919	10	28
PreEGO	20.15	5.00	-0.381	-0.288	8	28
PostEGO	19.92	4.32	-0.142	-0.148	10	28
PreTV	33.88	6.06	-0.566	-0.443	21	42
PostTV	34.39	5.70	-0.510	-0.445	19	42
PreCOLB	21.75	3.96	-1.05	1.80	8	28
PostCOLB	22.28	3.40	0.014	-0.880	16	28
PreSELB	41.90	9.12	-0.545	-0.203	20	56
PostSELB	42.25	8.96	-0.907	0.938	16	56
PreTA	18.11	6.00	-0.231	-0.556	5	32
PostTA	18.60	5.06	-0.505	-0.322	7	28

As it is seen in this table, an increase in mean scores was observed for TV, COLB and SELB and TA. Skewness and kurtosis values are in range between -2 and +2.

Descriptive statistics related with the pre and post test scores of IGO, EGO, TV, COLB, SELB and TA for the CG were giben in Table 4.3.

Table 4.4 Descriptive statistics related with the pre and post test scores of IGO, EGO,TV, COLB, SELB, TA for the CG

Variables	Mean	SD	Skewness	Kurtosis	Min.	Max.
PreIGO	19.74	3.52	0.201	-0.495	12	28
PostIGO	17.73	4.74	-0.112	0.450	4	28
PreEGO	19.68	5.03	-0.994	1.332	4	27
PostEGO	18.25	4.35	-0.440	0.713	6	28
PreTV	33.07	5.45	-0.707	0.390	17	42
PostTV	30.36	6.06	-0.178	-0.730	18	42
PreCOLB	21.95	3.47	-0.252	0.071	12	28
PostCOLB	20.35	3.96	-0.005	-0.538	13	28
PreSELB	41.52	6.94	-0.343	0.479	22	55
PostSELB	37.96	8.34	-0.486	0.818	12	55
PreTA	20.65	6.48	-0.300	-0.384	5	32
PostTA	20.41	5.85	0.185	-0.372	8	33

In table 4.4 for all variables IGO, EGO, TV, COLB, SELB and TA an decrease in mean scores was observed. Skewness and kurtosis values are also in range between -2 and +2.

When the mean scores from the pre administration of the instruments and post administrations of all variables were compared, EG students' TV, COLB, SELB and TA scores while an decrease from other variables in both groups was observed. The gain scores with respect to group membership are given in Table 4.5.

Table 4.5 Gain scores in the IGO, EGO, TV, COLB, SELB and TA with respect to group membership

Test	Group	Gain Score Mean	Skewness	Kurtosis
IGO	EG	-0.98	-0.185	0.264
	CG	-1.9	0.476	1.405
EGO	EG	-0.22	0.593	0.665
	CG	-1.4	0.255	1.885
TV	EG	0.49	-0.037	0.164
	CG	-0.23	0.108	1.910
COLB	EG	0.49	-0.037	0.164
	CG	-0.23	0.108	1.910
SELB	EG	0.34	0.165	0.385
	CG	-3.5	-0.512	0.191
TA	EG	0.49	-0.037	0.164
	CG	-0.23	0.108	1.910

Table 4.3, Table 4.4 and Table 4.5 shows the skewness and kurtosis values for pretest, posttest, and gain scores for the IGO, EGO, TV, COLB, SELB and TA. All of these values changes between -2 and +2 so the distribution of pretest, posttest, and gain scores of tests were normally distributed.

4.1.3 Descriptive Statistics of the Learning Strategies Scale

Descriptive statistics related with the pre and post test scores of REH, ELA, ORG, CT, MESR, TMES, ER, PL and HS for the EG were presented in Table 4.6.

Table 4.6 Descriptive statistics related with the pre and post test scores of REH, ELA,ORG, CT, MESR, TMES, ER, PL,HS for the EG

Variables	Mean	SD	Skewness	Kurtosis	Min.	Max.
PreREH	18.48	5.42	-0.082	-0.796	9.00	28.00
PostREH	18.01	4.99	-0.229	-0.071	6.00	28.00
PreELA	28.71	6.65	-0.150	-0.347	14.00	42.00
PostELA	30.15	6.79	-0.234	-0.349	13.00	42.00
PreORG	19.38	3.85	-0.155	-0.264	10.00	28.00
PostORG	19.46	4.97	-0.120	-0.576	8.00	28.00
PreCT	20.34	5.93	-0.358	-0.174	5.00	32.00
PostCT	20.88	5.83	0.212	-0.426	11.00	35.00
PreMETA	60.02	9.61	-0.313	1.136	31.00	84.00
PostMETA	62.09	9.41	0.288	-0.139	45.00	84.00
PreTMES	42.32	7.37	-0.484	-0.554	24.00	55.00
PostTMES	41.01	7.43	-0.216	-0.254	23.00	56.00
PreER	21.24	4.16	-0.672	-0.115	11.00	28.00
PostER	21.03	3.72	-0.606	1.019	9.00	28.00
PrePL	11.34	3.55	0.221	0.371	3.00	21.00
PostPL	12.80	3.78	0.249	-0.399	6.00	21.00
PreHS	19.04	5.37	-0.747	0.083	4.00	28.00
PostHS	20.22	4.99	-0.930	1.518	4.00	28.00

From Table 4.6 it can be seen that the skewness and kurtosis values were ranged between -2 and +2. Moreover, when the mean scores from the pre administration of the instruments and post administrations of them were compared, EG students' ELA, META, PL and HS scores increased from 28.71 to 30.15 ; 60.02 to 62.09; 11.34 to 12.8 and from 19.04 to 20.22.

Descriptive statistics related with the pre and post test scores of REH, ELA, ORG, CT, META, TSEM, ER, PL and HS for the CG were given in Table 4.7.

Table 4.7 Descriptive statistics related with the pre and post test scores of REH, ELA, ORG, CT, MESR, TSEM, ER, PL, HS for the CG

Variables	Mean	SD	Skewness	Kurtosis	Min.	Max.
PreREH	18.89	4.63	-0.512	-0.384	7.00	26.00
PostREH	18.92	4.06	-0.013	0.623	8.00	28.00
PreELA	28.12	6.54	0.038	-0.855	14.00	39.00
PostELA	27.56	6.63	-0.474	-0.318	11.00	39.00

Table 4.7(continued)

PreORG	19.34	4.45	-0.271	0.150	8.00	28.00
PostORG	18.50	4.45	-0.062	-0.256	10.00	28.00
PreCT	21.28	5.67	0.080	-0.470	9.00	34.00
PostCT	20.85	5.48	-0.444	0.551	5.00	32.00
PreMETA	60.37	9.04	-0.191	0.058	41.00	81.00
PostMETA	56.03	10.7	-0.140	-0.489	30.00	77.00
PreTSEM	42.38	5.89	-0.167	0.137	26.00	54.00
PostTSEM	38.38	6.65	-0.163	-0.821	26.00	51.00
PreER	20.66	4.30	-0.743	0.385	9.00	27.00
PostER	18.21	3.80	0.231	0.455	8.00	28.00
PrePL	12.59	3.71	0.103	-0.988	5.00	19.00
PostPL	13.91	3.11	-0.309	0.016	5.00	20.00
PreHS	20.08	4.06	-0.556	0.778	7.00	28.00
PostHS	19.37	3.29	-0.106	-0.464	12.00	26.00

As seen in Table 4.7, the mean scores from the pre administration of the instruments and post administrations of CG students' REH and PL scores increased from 18.89 to 18.92; 12.59 to 13.91. An decrease was observed other all variables in CG. The skewness and kurtosis values were also ranged between -2 and +2.

The gain scores with respect to group membership for REH, ELA, ORG, CT, META, TSEM, ER, PL and HS are given in Table 4.8.

Table 4.8 Gain scores in the REH, ELA, ORG, CT, META, TSEM, ER, PL and HS with respect to group membership

Test	Group	Gain Score Mean	Skewness	Kurtosis
REH	EG	-0.46	.059	-0.115
	CG	0.03	-.191	1.420
ELA	EG	1.43	.253	0.458
	CG	-0.56	0.405	0.189
ORG	EG	0.08	0.378	1.080
	CG	-0.83	-0.247	0.122
CT	EG	0.52	0.621	1.370
	CG	-0.42	-0.118	0.831
META	EG	2.06	0.799	0.817
	CG	-4.33	-0.385	0.347
TSEM	EG	-1.30	-0.117	0.148
	CG	-4.00	0.082	1.000

Table 4.8 (continued)

ER	EG	-0.20	0.322	0.323
	CG	-2.45	-0.107	-0.147
PL	EG	1.45	-0.029	0.203
	CG	1.31	-0.074	0.512
HS	EG	1.18	0.717	2.154
	CG	-0.71	0.093	-0.003

According to the Tablo 4.8, it is seen that when the mean scores from the pre and post administrations of all variables were compared, EG students' test scores increased except REH and TSEM. While CG students' test scores decreased except REH and PL. All of gain score' skewness and kurtosis values except HS kurtosis value of EG, changes between -2 and +2.

4.2 Inferential Statistics

In this section missing data analysis, determination of the covariates, verification of the assumptions of MANCOVAs, statistical model of MANCOVAs, and the analysis of the hypothesis were all presented.

4.2.1 Determination of the Covariates

In present study, three MANCOVAs were conducted to test the null hypothesis. Before conducting the first MANCOVAs for comparing PostBMAT and PostMPST for the first null hypothesis, two independent variables namely the PreBMAT and the PreMPST were pre-determined as potential confounding variables of this study. Thus, these independent variables were taken as covariates in order to statistically equalize the differences between the EG and CG. In order to determine which of these should be considered as covariates, these potential covariates were correlated with the dependent variables. The correlations between the pre-determined covariates and dependent variables were calculated and tested for their statistical significance to decide which variables should be selected as covariates in MANCOVA. The results of the correlations and their significance appear in Table 4.9.

Table 4.9 Pearson correlation coefficients between pre and post intervention BMAT and MPST

	PostBMAT	PostMPST
PreBMAT	0.292*	0.220*
PreMPST	0.205*	0.575*

* p< 0.05

As seen in Table 4.9, both the PreBMAT and the PreMPST have significant correlations with at least one of the dependent variables.

For the second MANCOVA used for comparing the PostIGO, the PostEGO, the PostTV, the PostCOLB, the PostSELP and the PostTA; the PreIGO, the PreEGO, the PreTV, the PreCOLB, the PreSELP, and the PreTA for the second null hypothesis were determined as potential confounding variables. To determine whether these pre-determined covariates, have significant correlation, Pearson correlation coefficient is used. The results and their significances is given in Table 4.10.

Table 4.10 Pearson correlation coefficients between pre and post intervention IGO, EGO, TV, COLB, SELB and TA

	PostIGO	PostEGO	PostTV	PostCOLB	PostSELP	PostTA
PreIGO	0.527*	0.094	0.370*	0.337*	0.347*	0.190*
PreEGO	0.075	0.632*	0.197*	0.123	0.119	0.318*
PreTV	0.454*	0.223*	0.677*	0.477*	0.536*	0.018
PreCOLB	0.100	0.051	0.230*	0.368*	0.146	-0.002
PreSELP	0.283*	0.268*	0.403*	0.242*	0.557*	0.073
PreTA	-0.139	0.169	-0.171	-0.161	-0.212*	0.408*

* p< 0.05

As seen in Table 4.10, every pre- determined covariates has significant corrrelation with at least one of the six dependent variables, so all of them are included as covariates set for this MANCOVA comparing posttests scores.

For the last MANCOVA used for comparing the PostREH, the PostELA, the PostORG, the PostCT, the PostMETA, the PostTSEM, the PostER, the PostPL and the PostHS; the PreREH, the PreELA, the PreORG, the PreCT, the PreMETA, the PreTSEM, the PreER, the PrePL and the PreHS were determined as potential confounding variables for the third null hypothesis. To determine whether these pre-determined covariates, have significant correlation, Pearson correlation coefficient is used. The results and their significances is given in Table 4.11.

Table 4.11 Pearson correlation coefficients between pre and post interventions scores of categories of learning strategies

	Dependent Variables								
	PostREH	PostELA	PostORG	PostCT	PostMETA	PostTSEM	PostER	PostPL	PostHS
PreREH	0.716*	0.418*	0.427*	0.364*	0.495*	0.268	0.016	0.325*	0.266
PreELA	0.405*	0.601*	0.396*	0.450*	0.586*	0.288*	0.317*	0.325*	0.319*
PreORG	0.449*	0.430*	0.470*	0.374*	0.492*	0.295*	0.167	0.330*	0.333*
PreCT	0.362*	0.489*	0.397*	0.586*	0.450*	0.189*	0.144	0.306*	0.301*
PreMETA	0.512*	0.493*	0.460*	0.298*	0.643*	0.414*	0.333*	0.258*	0.265*
PreTSEM	0.356*	0.353*	0.326*	0.272*	0.451*	0.612*	0.434*	0.184	0.215*
PreER	0.304*	0.378*	0.446*	0.161	0.554*	0.447*	0.517*	0.181	0.299*
PrePL	0.429*	0.371*	0.362*	0.384*	0.362*	0.157	0.000	0.354*	0.300*
PreHS	0.156	0.098	-0.009	0.123	0.160	0.138	-0.020	0.120	0.426*

* $p<0.05$

As seen in Table 4.11, all potential covariates has significant correlations with at least one of dependent variables. Thus, all of potential covariates were considered as covariates.

4.2.2.Assumptions of MANCOVA

For analysis of MANCOVA there were five underlying assumptions that need to be verified. These assumptions were; normality, homogeneity of regression, equality of variances, multicollinearity and independency of observations.

The first one of these assumptions was normality. For this assumption, skewness and kurtosis values were examined for all of the three MANCOVA Model. The skewness and kurtosis values of pre-test, post-tests and gain scoes for BMAT, MPST, IGO, EGO, TV, COLB, SELB, TA, REH, ELA, ORG, CT, META, TSEM, ER, PL and HS were acceptable range for a normal distribution, as seen in table 4.3, 4.4, 4.5 and 4.6.

A distribution having skewnessand kurtosis values between -2 and +2 can be accepted as normal distribution (George & Mallery, 2003, pp.98-99). Only the kurtosis values of the PostMPST and gain score of HS exceed ±2 a little bit. The Central Limit Theorem stated that regardless of the distribution of variables, sampling distributions of means will be normally distributed if sample size is large larger or equal to 30 (Gravetter & Wallnau, 2004). Therefore, in the present study, large kurtosis values were not expected to threaten the validity of the MANOVA results. This was not a serious violation.

Multivariate normality assumption was tested with Box's test of equality of covariance matrices. According to the results of analysis, nonsignificant Box's Test result was found for MANCOVA used for comparing posttests scores of BMAT, MPST, and comparing posttests scores of IGO, EGO, TV, COLB, SELP and TA [F (3, 2536628) = 0.089, p =0.966 and F (21, 42413) = 0.718, p = 0.81] respectively. Thus multivariate normality assumptions were satisfied for these MANCOVAs.

Additionally, a significant Box's Test result was found matrices for the MANCOVA comparing posttests scores of REH, ELA, ORG, CT, META, TSEM, ER, PL and HS [F (45, 37894) = 1.473, p =0.021]. Therefore, homogeneity of variance and covariance matrices for this MANCOVA was not met. But a violation of this assumption has minimal impact. If sample size of the largest group divided by the sample size of the smallest group is smaller than 1.5, the violation of this assumption has minimal effects (Hair, Anderson, Black & Tatham, 1998, p.348).

The next assumption is the equality of variance which was determined by Levene's Test of Equality. The Levene's Test of equality of error variances for the first MANCOVA used for comparing posttest scores of BMAT and MPST is given in Table 4.12.

Table 4.12 Levene's test of equality of error variances for the MANCOVA used for comparing posttest scores of BMAT, MPST

	F	df1	df2	Sig.
POSTBMAT	0.034	1	108	0.854
POSTMPST	0.038	1	108	0.845

As seen in Table 4.12, the p values for both of the dependent variables were higher than 0.05. So, it was concluded that the error variances of the two dependent variables across groups were equal. In Table 4.13 it was presented the Levene's Test of equality of error variances for the second MANCOVA used for comparing posttest scores of IGO, EGO, TV, COLB, SELP and TA.

Table 4.13Levene's test of equality of error variances for the MANCOVA used for comparing posttest scores of IGO, EGO, TV, COLB, SELP and TA

	F	df1	df2	sig
PostIGO	2.595	1	108	0.110
PostEGO	0.579	1	108	0.448
PostTV	0.765	1	108	0.384
PostCOLB	0.861	1	108	0.356
PostSELP	0.681	1	108	0.411
PostTA	0.052	1	108	0.819

In Table 4.13, as it appears, the p-values for six dependent variables were higher than 0.05. This indicates the error variances of six dependent variables across groups were equal and lastly the Levene's Test of equality of error variances for the MANCOVA used for comparing posttest scores of REH, ELA, ORG, CT, MESR, TSEM, ER, PL and HS, respectively was given in Table 4.14.

Table 4.14 Levene's test of equality of error variances for the MANCOVA used for comparing posttest scores of REH, ELA, ORG, CT, MESR, TSEM, ER, PL and HS

	F	df1	df2	sig
PostREH	0.279	1	108	0.598
PostELA	0.206	1	108	0.651
PostORG	0.516	1	108	0.474
PostCT	0.174	1	108	0.677
PostMETA	2.093	1	108	0.151
PostTSEM	1.299	1	108	0.257
PostER	0.041	1	108	0.840
PostPL	0.195	1	108	0.660
PostHS	1.844	1	108	0.177

It was indicated fom Table 4.14, the error variances of nine dependent variables across groups were equal. As it is seen in table 4.12, 4.12 and 4.14, all F values were found non-significant which indicates that the error variances of the dependent variables across groups were equal for all analyses.

For the multicollinearity assumptions, the correlations between covariates were examined. Multicollinearity refers to the existence of high correlation among a set of independent variables (Cohen & Cohen, 1983, p.115). Correlations among covariates were examined in order to check this assumption. The correlation coefficient was found 0.31. So it can be said that there was no multicollinearity among the three covariates for this analyse because correlation coefficient was smaller than 0.80.

For the second MANCOVA, correlations among covariates; the PreIGO, the PreEGO, the PreTV, the PreCOLB, the PreSELP, the PreTA and their significance are given in Table 4.18 respectively.

Table 4.15 Correlations between covariates; the PreIGO, the PreEGO, the PreTV, the PreCOLB, the PreSELP, the PreTA

	PreEGO	PreTV	PreCOLB	PreSELP	PreTA
PreIGO	0.163	0.475*	0.314*	0.322*	0.101
PreEGO		0.264*	0.121	0.289*	0.359*
PreTV			0.348*	0.578*	-0.079
PreCOLB				0.253*	0.013
PreSELP					-0.086

* p<0.05

As seen in Table 4.15, the maximum value of correlations among covariates was 0.578. So it can be said that there was no multicollinearity among the six covariates for this anaylse. Therefore, it can be said that there is no interaction effect of covariates on posttest scores; and so this assumption was validated. For the last MANCOVA, correlations among covariates; the PreREH, the PreELA, the PreORG, the PreCT, the PreMETA, the PreTSEM, the PreER, the PrePL, the PreHS and their significance are given in Table 4.16 respectively.

Table 4.16 Correlations between covariates; the PreREH, the PreELA, the PreORG, the PreCT, the PreMETA, the PreTSEM, the PreER, the PrePL, the PreHS

	PreELA	PreORG	PreCT	PreMETA	PreTSEM	PreER	PrePL	PreHS
PreREH	0.536*	0.599*	0.457*	0.518*	0.177	0.314*	0.389*	0.267*
PreELA		0.561*	0.626*	0.699*	0.256*	0.371*	0.459*	0.356*
PreORG			0517*	0.590*	0.224*	0.254*	0.505*	0.287*
PreCT				0.483*	0.203*	0.177	0.515*	0.168
PreMETA					0.403*	0.482*	0.449*	0.273*
PreTSEM						0.444*	0.207*	0.264*
PreER							0.107	0.088
PrePL								0.423*

* p<0.05

By similarly, it can be said that there was no multicollinearity among the PreREH, the PreELA, the PreORG, the PreCT, the PreMETA, the PreTSEM, the PreER, the PrePL, the PreHS for the last MANCOVA analyse.

The next assumption is homogeneity of regression slopes. Homogeneity of regression assumption means that the regression of dependent variables on covariates must be constant over different values of a group membership. In order to check this assumption, linear regression analysis was conducted. Covariate variables were set to Block 1, group membership was set to Block 2 and the interaction terms set to Block 3 (Block 1* Block 2). Then, to test the significance of R^2 change, the regression analysis was performed using enters method for each variable. If the interactions were significant, then the homogeneity of the regression assumption would be violated (Stevens, 2002). To check this assumption, it is possible to use univariate analysis and form interaction sources between each covariate and the factor assessed in the prediction of the dependent variable. In the present study, linear regression analyse was used.

For the MANCOVA used for comparing posttests of BMAT and MPST, three interaction terms were produced by multiplying the group membership with the covariates; the PreBMAT and the PreMPST. Table 4.17 shows the result of the regression analysis.

Table 4.17 Analysis of the homogeneity of regression assumption in MANCOVA comparing posttests scores of BMAT and MPST

Model	Change Statistics				
	R^2 Change	F Change	df1	df2	Sig. F Change
PostBMAT					
Block 1	0.100	5.931	2	107	0.004
Block 2	0.050	6.250	1	106	0.014
Block 3	0.044	2.840	2	104	0.063
PostMPST					
Block 1	0.332	26.604	2	107	0.000
Block 2	0.165	34.681	1	106	0.000
Block 3	0.014	1.506	2	104	0.227

As it is seen from this table, the contribution of Block 3 (Block1*Block2) is not significant for the PostBMAT and the PostMPST. As a result, a non significant interaction between the factor and covariates suggested that the differences on the dependent variables among groups did not vary as a function of the covariates.

For the second MANCOVA used for comparing posttests of IGO, EGO, TV, COLB, SELP and TA, six interaction terms were produced by multiplying the group membership with the covariates; the PreIGO, the PreEGO, the PreTV, the PreCOLB, the PreSELB, the PreTA. Table 4.22 shows the result of the regression analysis.

Table 4.18 Analysis of the homogeneity of regression assumption in MANCOVA comparing posttests scores of IGO, EGO, TV, COLB, SELP and TA

Model	Change Statistics				
	R^2 Change	F Change	df1	df2	Sig. F Change
PostIGO					
Block 1	0.373	10.234	6	103	0.000
Block 2	0.016	2.690	1	102	0.104
Block 3	0.041	1.161	6	96	0.334
PostEGO					
Block 1	0.413	12.067	6	103	0.000
Block 2	0.023	4.087	1	102	0.046
Block 3	0.019	.565	6	96	0.758
PostTV					
Block 1	0.483	16.038	6	103	0.000
Block 2	0.068	15.526	1	102	0.000
Block 3	0.036	1.376	6	96	0.232
PostCOLB					
Block 1	0.313	7.812	6	103	0.000
Block 2	0.045	7.218	1	102	0.008
Block 3	0.056	1.536	6	96	0.175
PostSELB					
Block 1	0.422	12.533	6	103	0.000
Block 2	0.038	7.195	1	102	0.009
Block 3	0.017	.518	6	96	0.794
PostTA					
Block 1	0.228	5.068	6	103	0.000
Block 2	0.009	1.229	1	102	0.270
Block 3	0.037	.826	6	96	0.552

As it is seen from this table, the contribution of Block 3 (Block1*Block2) is not significant for the PostIGO, the PostEGO, the PostTV, the PostCOLB, the PostSELB, the PostTA. For this MANCOVA, a non significant interaction between the factor and covariates suggested that the differences on the dependent variables among groups did not vary as a function of the covariates. This means that the homogeneity of regression assumption is validated for this model.

Similarly, for the third MANCOVA used for comparing posttests of REH, ELA, ORG, CT, MESR, TSEM, ER, PL and HS nine interaction terms were produced by multiplying the group membership with the covariates. Results are presented in Table 4.19.

Table 4.19 Analysis of the homogeneity of regression assumption in MANCOVA comparing posttests scores of REH, ELA, ORG, CT, MESR, TSEM, ER, PL, and HS

Model	Change Statistics				
	R^2 Change	F Change	df1	df2	Sig. F Change
PostREH					
Block 1	0.476	10.104	9	100	0.000
Block 2	0.003	0.605	1	99	0.439
Block 3	0.072	1.604	9	90	0.126
PostELA					
Block 1	0.471	9.904	9	100	0.000
Block 2	0.032	6.389	1	99	0.013
Block 3	0.064	1.468	9	90	0.172
PostORG					
Block 1	0.432	8.437	9	100	0.000
Block 2	0.010	1.767	1	99	0.187
Block 3	0.042	0.807	9	90	0.611
PostCT					
Block 1	0.405	7.578	9	100	0.000
Block 2	0.002	0.263	1	99	0.609
Block 3	0.048	0.883	9	90	0.544
PostMETA					
Block 1	0.569	14.658	9	100	0.000
Block 2	0.080	22.498	1	99	0.000
Block 3	0.012	0.340	9	90	0.959

Table4.19 (continued)

PostTSEM					
Block 1	0.448	9.013	9	100	0.000
Block 2	0.030	5.626	1	99	0.020
Block 3	0.058	1.249	9	90	0.276
PostER					
Block 1	0.391	7.148	9	100	0.000
Block 2	0.080	14.882	1	99	0.000
Block 3	0.033	0.660	9	90	0.743
PostPL					
Block 1	0.193	2.662	9	100	0.008
Block 2	0.021	2.617	1	99	0.109
Block 3	0.049	0.671	9	90	0.733
PostHE					
Block 1	0.307	4.923	9	100	0.000
Block 2	0.020	3.002	1	99	0.086
Block 3	0.080	1.352	9	90	0.222

From Table 4.19, it can be understood that the interaction terms did not result in significance for each dependent variable. Hence, there was no significant interaction between the covariates and the independent variables. As a result homogenity of regression slope assumption is satisfied for all MANCOVA Model for this study.

The last one of these assumptions is independence of observations. To validate this assumption the researcher observed both groups during the administration of all pre and posttest. From the observations it can be mentioned that all subjects did all the tests by themselves.

4.3 Findings of Research Questions

In this part the findings of the analyses to test the null hypothesis related were presented in the order of related research questions.

4.3.1 Findings of the First Research Question

The null hypothesis related to the first research question of this study is as follows:

H_o1: There is no significant overall effect of different problem solving approaches on the collective dependent variables of the pre-service elementary school teachers' post test scores on basic achievement test and problem-solving performance test when participants' pre-test scores on basic achievement test and problem-solving performance test are controlled.

The hypothesis was tested by a multivariate analysis of covariance (MANCOVA) at the significance level 0.05. The satisfaction of all assumption were tested and according to the analysis, all assumptions were satisfied for this MANCOVA Model. The results of assumption analysis were given in section 4.2. The covariates were used to statistically equalize pre-service teachers'characteristics. As the covariates of this study; the PreBMAT and the PreMPST were determined. Group membership with respect to two groups was named here as "Group" and used as fixed factor of this study. The results of this MANCOVA Model were illustrated in Table 4.20.

Table 4.20 Multivariate tests results for the MANCOVA comparing PostBMAT and PostMPST

Effect	Wilks' Lambda	F	Hypothesis df	Error df	Sig.	Eta Squared	Observed Power
Intercept	0.485	55.767	2.000	105.000	0.000	0.515	1.000
PreBMAT	0.855	8.918	2.000	105.000	0.000	0.145	0.969
PreMPST	0.872	7.712	2.000	105.000	0.001	0.128	0.944
Group	0.735	18.931	2.000	105.000	0.000	0.265	1.000

As it is seen from the Table 4.20, the PreBMAT and the PreMPST were statistically significant covariates at 0.05 significance level. Furthermore, there is a statistically significant overall effect of different problem solving approach on the collective dependent variables of the PostBMAT and PostMPST when the PreBMAT and PreMPST were controlled [$F(2, 105) = 18.931$, Wilks' $\lambda=0.73$, $p=0.000$]. According to the Table 4.20, the multivariate $\eta 2 = 0.265$ based on Wilks' λ was large by utilizing the guidelines proposed by Cohen and Cohen (1983). This $\eta 2=0.265$, infered as 26.5% of the total variance of model for the collective dependent variables of the PostBMAT and PostMPST was explained by the treatment.

According to the Table 4.23, it is seen that observed power of the study is

1.000. This is higher than the calculated power of the study, which was 0.80 (explained in section 3.10).

Analyses of covariances (ANCOVA) on each dependent variable were conducted as follow-up tests to the MANCOVA. In ANCOVA the hypothesis-wise alpha level was divided by 2 which is the number of dependent variables (Green & Salkind, 2004, p.224). Table 4.21 presents the results of the ANCOVA.

Table 4.21 Follow- up Pairwise Comparison for the MANCOVA comparing PostBMAT and PostMPST

Dependent Variable	Groups	Mean	SD	F	Sig.	df	Partial η^2	Observed Power
PostBMAT	EG	37.37	8.84	6.250	0.014*	1,106	0.056	0.698
	CG	34.16	9.11					
PostMPST	EG	51.71	11.73	34.681	0.000*	1,106	0.247	1.000
	CG	36.82	11.10					

p*<0.025

From the Table 4.21, a statistically significant mean difference was seen for the PostBMAT between groups in the favor of questioning problem solving approach [$F(1,106) = 6.25$, $p=0.014<0.025$, $\eta^2=0.056$]. It can be inferred that students in questioning problem solving approach had higher scores on posttest than the students in traditional problem solving approach($M_{EGPostBMAT}=37.37$, $SD_{EGPostBMAT}=8.84$; $M_{CGPostBMAT}=34.16$, $SD_{CGPostBMAT}=9.11$).

The eta squared for the posttest scores of the BMAT was approximately 0.06 and this value was equal to small effect size (Cohen & Cohen, 1983). This indicated that approximately 6 % of multivariate variance of the PostBMAT was associated with the group factor. Moreover, observed power for posttest scores of the BMAT was 0.698.

Additionally, it can be seen clearly from, there is a statistically significant mean difference for the PostMPST between groups in the favor of questioning problem solving approach [$F(1,106)=34.68$, $p=0.000<0.025$,

η^2=0.247]. According to the results it can said that students in questioning problem solving approach had higher scores on posttest than the students in traditional problem solving approach ($M_{EGPostMPST}$=51.71, $SD_{EGPostMPST}$=11.73; $M_{CGPostMPST}$=36.82, $SD_{CGPostMPST}$=11.10).

The multivariate $\eta 2$ = 0.247 was found for PostMPST. This was large effect size (Cohen and Cohen, 1983) indicated that approximately 25% of multivariate variance of the PostMPST was associated with the group factor and the observed power for posttest scores of the MPST was found 1.000.

4.3.2 Findings of the Second Research Question

The second null hypothesis related to the second research question of this study is as follows:

H_o2: There is no significant overall effect of different problem solving approaches on the collective dependent variables of pre-service elementary school teachers' post test scores on intrinsic and extrinsic goal orientation, task value, control of learning beliefs, self-efficacy for learning and performance, and test anxiety when participants' pre-test scores on each variable are controlled.

Second MANCOVA was conducted to test the hypothesis at the significance level 0.05. All of the assumptions of this MANCOVA Model were satisfied. The results of assumption analysis were given in section 4.2.2. The PreIGO, the PreEGO, the PreTV, the PreCOLB, the PreSELB and the PreTA were determined as the covariates of this analyse. Group membership with respect to two groups was named here as "Group" and used as fixed factor. The results of this MANCOVA Model were illustrated in Table 4.22.

Table 4.22 Multivariate tests results for the MANCOVA comparing PostIGO, PostEGO, PostTV, PostCOLB, PostSELP and PostTA

Effect	Wilks' Lambda	F	Hypothesis df	Error df	Sig.	Eta Squared	Observed Power
Intercept	0.801	4.014	6.000	97.000	0.001	0.199	0.965
PreIGO	0.785	4.432	6.000	97.000	0.001	0.215	0.979
PreEGO	0.665	8.146	6.000	97.000	0.000	0.335	1.000
PreTV	0.681	7.590	6.000	97.000	0.000	0.319	1.000
PreCOLB	0.872	2.378	6.000	97.000	0.035	0.128	0.792
PreSELP	0.800	4.045	6.000	97.000	0.001	0.200	0.967
PreTA	0.847	2.909	6.000	97.000	0.012	0.153	0.878
Group	0.776	4.664	6.000	97.000	0.000	0.224	0.985

According to the Table 4.22, The PreIGO, the PreEGO, the PreTV, the PreCOLB, the PreSELB and the PreTA were statistically significant covariates at 0.05 significance level. More over, it can be seen, there is significant overall effect of different problem solving approach on the collective dependent variables PostIGO, PostEGO, PostTV, PostCOLB, PostSELB, PostTA when the pre-test scores of IGO, EGO, TV, COLB, SELB and TA were controlled [$F(6,97)=4.664$, Wilks'$\lambda=0.77$, $p=0.000$]. The multivariate η^2 was found 0.224 and this indicated that approximately 23% of multivariate variance of the dependent variables was associated with group factor.

In Table 4.22, it is seen that observed power of the study is 0.985. This value is higher than the calculated power of the study, which was 0.80 (explained in section 3.3).

Analyses of covariances (ANCOVA) on each dependent variable were conducted as follow-up tests to the MANCOVA. Each ANCOVA was conducted at alpha level of 0.0083. Table 4.23 presents the results of the ANCOVA.

Table 4.23 Follow-up Pairwise Comparison for the MANCOVA comparing PostIGO, PostEGO, PostTV, PostCOLB, PostSELP and PostTA

Dependent Variable	Groups	Mean	SD	F	Sig.	df	Partial $\eta 2$	Observed Power
PostIGO	EG	19.16	5.04	2.690	0.104	1,102	0.026	0.369
	CG	17.73	4.74					
PostEGO	EG	19.92	4.32	4.087	0.046	1,102	0.039	0.517
	CG	18.25	4.35					
PostTV	EG	34.39	5.70	15.526	0.000*	1,102	0.132	0.974
	CG	30.36	6.06					
PostCOLB	EG	22.28	3.40	7.218	0.008*	1,102	0.066	0.758
	CG	20.35	3.96					
PostSELB	EG	42.25	8.96	7.195	0.009	1,102	0.066	0.757
	CG	37.96	8.34					
PostTA	EG	18.60	5.06	1.229	0.270	1,102	0.012	0.196
	CG	20.41	5.85					

$p^* < 0.0083$

As it is seen from the Table 4.23, there is a statistically significant mean difference for posttsest scores of TV between groups in the favor of questioning problem solving approach [$F(1,102)=15.526$, $p=0.000<0.0083$, $\eta^2=0.13$]. Therefore students in experimental group had higher scores on posttest than students in control group ($M_{EGPostTV}=34.39$, $SD_{EGPostTV}=5.70$; $M_{CGPostTV}=30.36$, $SD_{CGPostTV}=6.06$).

The multivariate $\eta 2=0.132$ of PostTV was (large effect size) indicated that 13.2% of multivariate variance of the PostTV was associated with the group factor and the observed power of this dependent variable was 0.97.

Additionally, it can be seen from Table 4.23, there’s a statistically significant mean difference for the PostCOLB between groups in the favor of questioning problem solving approach [$F(1,102)=7.218$, $p=0.008<0.0083$, $\eta^2=0.066$]. According to the results it can said that students in questioning problem solving approach had higher scores on posttest than the students in traditional problem solving approach ($M_{EGPostCOLB}=22.28$, $SD_{EGPostCOLB}=3.40$; $M_{CGPostCOLB}=20.35$, $SD_{CGPostCOLB}=3.96$).

The multivariate eta squared for the posttest scores of COLB was approximately 0.07. This indicated that approximately 7% of multivariate variance of the PostCOLB was associated with the group factor. Observed power for posttest scores of the COLB was 0.75.

Additionally, in Table 4.23, results indicated that there was no statistically significant mean difference between the experimental and the control groups with respect to intrinsic goal orientation, extrinsic goal orientation, self efficacy for learning and performance, and test anxiety. However, students in EG had higher mean scores on PostIGO and PostEGO, than the students in CG ($M_{EGPostIGO}=19.16$, $SD_{EGPostIGO}=5.04$; $M_{CGPostIGO}=17.73$, $SD_{CGPostIGO}=4.35$; $M_{EGPostEGO}=19.92$, $SD_{EGPostEGO}=4.32$; $M_{CGPostEGO}=18.25$, $SD_{CGPostEGO}=4.74$).

In addition, students in EG had higher mean scores on PostSELB than the students in CG ($M_{EGPostSELB}=42.25$, $SD_{EGPostSELB}=8.96$; $M_{CGPostSELB}=37.96$, $SD_{CGPostSELB}=8.34$). Lastly according to the Table 4.23 it can be seen that students in EG had lower mean scores on PostTA than the students in CG($M_{EGPostTA}=18.60$, $SD_{EGPostTA}=5.06$; $M_{CGPostTA}=20.41$, $SD_{CGPostTA}=5.85$).

4.3.3 Findings of the Third Research Question

The third null hypothesis related to the third research question of this study is as follows:

H_o3: There is no significant overall effect of different problem solving approaches on the collective dependent variables of the pre-service elementary school teachers' post test scores on rehersal, elaboration, organization, critical thinking, metacognitive self regulation, time and study environment management, effort regulation, peer learning and help seeking when participants' pre-test score on each variables are controlled.

To test the hypothesis last MANCOVA was conducted at the significance level 0.05. All of the assumptions of this MANCOVA Model were satisfied. The results of assumption analysis were given in section 4.2. The PreREH, the PreELA, the PreORG, the PreCT, the PreMETA, the PreTSEM, the PreER, the PrePL and the PreHS were determined as the covariates of this analyse. Group membership with respect to two groups was named here as "Group" and used as fixed factor. The results of this analysis were given in Table 4.24

Table 4.24 Multivariate tests results for MANCOVA comparing posttests scores of REH, ELA, ORG, CT, MESR, TSEM, ER, PL, and HS

Effect	Wilks' Lambda	F	Hypothesis df	Error df	Sig.	Eta Squared	Observed Power
Intercept	0.843	1.889	9.000	91.000	0.063	0.157	0.796
PreREH	0.744	3.481	9.000	91.000	0.001	0.256	0.982
PreELA	0.783	2.799	9.000	91.000	0.006	0.217	0.944
PreORG	0.906	1.047	9.000	91.000	0.410	0.094	0.489
PreCT	0.749	3.380	9.000	91.000	0.001	0.251	0.978
PreMETA	0.833	2.027	9.000	91.000	0.045	0.167	0.829
PreTSEM	0.693	4.472	9.000	91.000	0.000	0.307	0.997
PreER	0.716	4.014	9.000	91.000	0.000	0.284	0.993
PrePL	0.909	1.007	9.000	91.000	0.441	0.091	0.470
PreHS	0.709	4.144	9.000	91.000	0.000	0.291	0.994
Group	0.645	5.568	9.000	91.000	0.000	0.355	1.000

According to the Table 4. 24, it can be seen, the PreREH, the PreELA, the PreORG, the PreCT, the PreMETA, the PreTSEM, the PreER, the PrePL and the PreHS were statistically significant covariates at 0.05 significance level. Furthermore, it is seen that there is a statistically significant overall effect of different problem solving approach on the collective dependent variables of the PostREH, PostELA, PostORG, PostCT, PostMETA, PostTSEM, PostER, PostPL and PostHS when pretest scores of these variables were controlled [$F(9, 91)=5.568$, Wilks' $\lambda=0.64$, $p=0.000$]. The multivariate $\eta 2=0.35$ indicated that

35% of multivariate variance of the dependent variables was associated with group factor. In addition it is seen that observed power of the study is 1.000. This is higher than the calculated power of the study, which was 0.80 (explained in section 3.3).

Analyses of covariances (ANCOVA) on each dependent variable were conducted as follow-up tests to the MANCOVA. Each ANCOVA was conducted at alpha level of 0.0055. The results of this analysis were presented in Table 4.25.

Table 4.25 Follow- up pairwise comparison for MANCOVA comparing posttests scores of REH, ELA, ORG, CT, META, TSEM, ER, PL, and HS

Dependent Variable	Groups	Mean	SD	F	Sig.	df	Partial η^2	Observed Power
PostREH	EG	18.01	4.99	0.989	0.322	1,99	0.010	0.166
	CG	18.92	4.06					
PostELA	EG	30.15	6.79	6.337	0.013	1,99	0.060	0.703
	CG	27.56	6.63					
PostORG	EG	19.46	4.97	1.691	0.196	1,99	0.017	0.251
	CG	18.50	4.45					
PostCT	EG	20.88	5.83	0.169	0.682	1,99	0.002	0.069
	CG	20.85	5.48					
PostMETA	EG	62.09	9.41	23.003	0.000*	1,99	0.189	0.997
	CG	56.03	10.7					
PostTSEM	EG	41.01	7.43	5.490	0.021	1,99	0.053	0.641
	CG	38.38	6.65					
PostER	EG	21.03	3.72	15.582	0.000*	1,99	0.136	0.974
	CG	18.21	3.80					
PostPL	EG	12.80	3.78	2.679	0.105	1,99	0.026	0.368
	CG	13.91	3.11					
PostHS	EG	20.22	4.99	2.574	0.112	1,99	0.025	0.355
	CG	19.37	3.29					

* $p < 0.0055$ level

From the Table 4.25, it is seen, a statistically significant mean difference for posttsest scores of META between groups in the favor of questioning problem solving approach $F(1,99)=23.003$, $p=0.00<0.0055$, $\eta^2=0.189$]. Therefore students in experimental group had higher scores on posttest than students in control group ($M_{EGPostMETA}=62.09$, $SD_{EGPostMETA}=9.41$; $M_{CGPostMETA}=56.03$, $SD_{CGPostMETA}=10.7$).

The multivariate eta square of PostMETA was found approximately 0.19 (large effect size) and it was indicated that 19% of multivariate variance of the PostMETA was associated with the group factor. The observed power of this dependent variable was found 0.99.

Additionally, it can be seen from Table 4.25, there is a statistically significant mean difference for the PostER between groups in the favor of questioning problem solving approach [$F(1,99)=15.582$, $p=0.00<0.0055$, $\eta^2=0.136$]. According to the results it can said that students in questioning problem solving approach had higher scores on posttest than the students in traditional problem solving approach ($M_{EGPostER}=21.03$, $SD_{EGPostER}=3.72$; $M_{CGPostER}=18.21$, $SD_{CGPostER}=3.80$). The multivariate eta squared for the posttest scores of ER was approximately 0.14. This indicated that approximately 14% of multivariate variance of the PostER was associated with the group factor and the observed power for posttest scores of the ER was 0.97.

Additionally, in Table 4.25, results indicated that there was no statistically significant mean difference between the experimental and the control groups with respect to REH, ELA, ORG, CT, TSEM, PL and HS. But, students in EG had higher mean scores on PostELA, PostORG and PostCT than the students in CG ($M_{EGPostELA}=30.15$, $SD_{EGPostELA}=6.79$; $M_{CGPostELA}=27.56$, $SD_{CGPostELA}=6.63$; $M_{EGPostORG}=19.46$, $SD_{EGPostORG}=4.97$; $M_{CGPostORG}=18.50$, $SD_{CGPosORG}=4.45$; $M_{EGPosCT}=20.88$, $SD_{EGPostCT}=5.83$; $M_{CGPostCT}=20.85$, $SD_{CGPostCT}=5.48$).

Besides this, students in EG had higher mean scores on PostTSEM and PostHS than the students in CG ($M_{EGPostTSEM}=41.01$, $SD_{EGPostTSEM}=7.43$; $M_{CGPostTSEM}=38.38$, $SD_{CGPostTSEM}=6.65$; $M_{EGPostHS}=20.22$, $SD_{EGPostHS}=4.99$; $M_{CGPostHS}=19.37$, $SD_{CGPostHS}=3.29$).

In contrast to these findings, students in EG had lower mean scores on PostREH and PostPL than the students in CG $M_{EGPostREH}$=18.01, $SD_{EGPostREH}$=4.99; $M_{CGPostREH}$=18.92, $SD_{CGPostREH}$=4.06; $M_{EGPostPL}$= 12.80, $SD_{EGPostPL}$=3.78; $M_{CGPostPL}$=13.91, $SD_{CGPostPL}$=3.11).

4.3.4 Findings for the Fourth Research Question from Interviews

The interviews were conducted three times during the study to examine the fourth reserach question

"How does pre-service elementary school teachers' problem-solving performance change during the study according to Polya's problem solving phases?"

Interviews were done with 8 selected students with respect to their perivous year mathematics class. Under this aim every time two mathematical problems were asked to participants.

Student A, B, and C were selected from high achiever students, student D, E and F were selected from moderate achievement students and student G, H were selected from low achiever students randomly. To find the answer of this research question interview questions were prepared to the Polya's problem solving phases. The findings from all interviews can be summarized in Table 4.26.

Table 4.26. Findings of interviews

	Interview I (Before the treatment)								Interview II (Mid- time of the treatment)								Interview III (After the treatment)							
	Polya's four- phases								Polya's four- phases								Polya's four- phases							
Student	Problem 1				Problem 2				Problem 3				Problem 4				Problem 5				Problem 6			
	U	P	C	L	U	P	Cr	L	U	P	C	L	U	P	C	L	U	P	Cr	L	U	P	C	L
A	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
B	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
C	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
D	✓	✓			✓	✓			✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
E	✓	✓	✓		✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
F	✓	✓	✓		✓	✓	✓		✓	✓			✓	✓	✓		✓	✓	✓		✓	✓	✓	✓
G	✓	✓	✓		✓	✓			✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
H	✓	✓			✓	✓	✓		✓	✓		✓	✓	✓			✓	✓	✓		✓	✓	✓	✓

*U: Understanding; P: Devising a plan ; C: Carry out the plan; L: Look Back

According to the Table 4.26, from the first interviews which was conducted before the treatment, it was found that all students understood the problems and they made a plan to solve the problems. For the first problem except D and H, all students applied their plan and for the second problem samely except D and G, others applied their plans to solve the problem. All students were asked the question "What did you do first when you saw the problem?", and then according to the response of the student, "Could you understand the problem?" "What did you do to understand the problem?" All students gave the answer "I read and tried to understand". The answers of the students for the first problem, A and B are given as follows.

> *A: I read. I have a problem of reading for this kind of problems, sometimes I can not understand, that's why I read the problem over and over again, finally I understood.*
>
> *B: Firstly I read the question a couple of times and I understood. If I think that I will have difficulty, I generally underline the problem to understand and write down the input data, but I did not have difficulty for this problem.*

Another important finding as seen in the Table 4.30 that none of the students checked their answers in the first interviews. To the questions "Are you sure about your answer?" and "Have you checked your answer?", all of them, answered either "not sure", "have not checked", or "sure", "have not checked". Students, even if they were sure, did not check their answers. Some examples of their answers for the first problem as follows;

> *A: Something went wrong while doing the operations, I solved again to calculate through hours, but there was a mistake in operations. I am not sure about the solution, did not check…..I generally check if the result is not a whole number.*
>
> *C: I am not sure. I proofed it though, but I could not find*

which variable was what. I also did not understand how many days have passed. I could not check since I did not have time.

In the second interview, it can be seen clearly that all of the students understood the problems and they made a plan to solve the problem. In addition for application the plan phase approximately same number of students when comparing the number of students did in the first interview. For the third and fourth problems five students checked their solutions or they looked back the steps they did in their solutions. Some responds of students for the third problem are given as;

A: I am not sure and I checked. First, the result was meaningless, thus I read the problem a couple of times to check if there was something missing. After solving again, I found a more logical result. I thought that this relationship was a function, because if we determine the domain no elements remain outside, and each element matches with at least an element.

B: I am sure, I checked. First, I miscalculated and got a very big number, I tried again and even rounded the result up. I concluded that it's a function since I found a result, there was a relationship.. I know this is not enough but I could not go further.

C: I am sure. I checked my operations again since I did them manually. Also I used a calculator to check the accuracy of the operations..

I think that this relationship is a function. I tried to find a function confirming this relationship…

D: I am sure. I checked first and the result was 10 meters, I thought that a human height can not be 10 meters, then I figured out that I miscalculated. I calculated again, and this *time the result was logical... I am sure about the result and I checked.*

E: I replaced F with the value, and the result was 514 cm. I thought that the human height used to be this much in the past... I am not sure... I couldn't go further. I did not check.

In the last interviews it was found that all students understood the problems, made their plans and carry out their plans to find the answer. Moreover, six students for the fifth problem and eight students for the last problem checked their solutions for the last problem. Some example responses are given as follows.

A: I am sure, I checked the solution.
C: I am sure, I checked the solution.
E: I am not sure but I checked.
F: Yes I am sure, I checked the solution.
G: I am sure, I checked the solution…
H: I am sure I checked.

The important results of the interview process during the treatment is students had looking back skils when compared to the results of first interview.Once they tried the problem, found an answer then go back to the problem and verify their solutions.

4.3.5 Findings for the Fifth Research Question

“What are the opinions of pre-service elementary school teachers’ related to the effects of the questioning problem solving approach?”

Question 1:What is your opinion about the problems that we solved during the classes throughout the semester?

Responses to open-ended questions, loaded into four themes. These themes and examples of related responses were given as following;

- the problems enabled them to think differently (n=13)

"The problems were different than the Student Selection Examination type we got used to. They enabled us to rethink over and contemplate."

"The problems were different than those we encounter in the regular mathematics lesson, that is, they were based on thinking, questioning and reasoning. This was for us advantageous in that it enabled us to rethink."

- the problem were required reasoning (n=10)

"The problems were related to daily life and required attention. They necessitated reasoning and were mathematically very telling".

"According to me the problems given to us wererequired reasoning. That is, in general they required thinking instead of sticking to a formula. It was a very worthy method in that it enables us to rethink".

- the problems were about the everyday life, (n=7)

"It was very nice contemplating carefully on the problems with my friends for some time. We found the answers to most of the problems that used to make us question how to use the subjects in daily life in this lesson. It enabled us to understand the subject better, to deduce the stable rules to daily life, and to relate mathematics to daily life".

"The problems were about current subjects related to daily life."

- enabled us to understand the content better, (n=5)

"The problems were wittingly chosen. I could say that they provide the essence, the main idea of the subject. At the same time, I could tell that some verbal problems made it easier to remember the subject."

"At the beginning it seemed as if the problems had nothing to do with the subject but they were sharply tricky. The problems were chosen well. I could say that they present the core of the subject."

Question 2: What is your opinion about the problem solving approach, which applied in Basic Mathematics Course during the semester?

Related responses about this qustion were loaded into four themes. These themes and examples of related responses were given as following;

- problem solving way especially useful, (n=14)

"Honestly, I was very surprised at the beginning; then I realized that this method was especially useful for us".

"It is very helpful first to deal with the problem alone, and then to discuss it with colleagues. I enjoyed referring to the hint sheet."

- this way was different than the other tought in mathematics class, (n=11)

"We were not familiar with the way the subject was treated. Treating the subject with problems enabled us to comprehend mathematics and think logically."

"The way the subject was treated was so different than the mathematics class we have been to so far. In general the teacher presents the subject and solves related problems."

- at the beginning it was difficult, (n=7)

"It was very different than the mathematics class that we were accustomed to. At the beginning it was difficult because I was not able to solve the problems but afterwards it became engaging."

"I had some difficulties at the beginning, but I easily got used to this process. The semester was fruitful for me. My high grades could be an indicator of it".

- problem solving was rather entertaining, (n=10)

"Problem solving session was rather entertaining. It developed curiosity in me conferring to our friends or to the hint sheets

when we were not able to solve the problem".

"I think the way the subject was treated was very amusing. It increased my curiosity for solving problems to think over a problem by ourselves, and when we cannot solve it, to confer with a friend or to use the hint sheets."

Question 3: According to you, is there any positive behavior that the questioning problem solving endowed you with?

According to the results, responses were loaded into three loaded into themes. These themes and examples of related responses were given as following;

- Learn to solve the problems in different ways, (n=14)

"It enabled us to develop and find out new ways of problem solving to try to solve the problems by ourselves. I learnt that we could solve the problems in diverse ways".

"The problems enabled me to develop diverse strategies for them and other problem solving methods."

- Learn to think differently, (n=14)

"I learnt to think differently and to take a different approach. It was very logical first to solve the problems alone and then to seek advice from our friends or the hint sheets. I consider using the same method with my students in the future."

"Thinking differently compelled us and taught us to think another way."

- use problems in their classes in the future, (n=3)

"I observed that I started to consider solvable the problems we used to call unsolvable by learning problem solving ways or seeing that I was able to solve them. I would like to ask these problems to my pupils when I become a teacher."

"I will apply the same method when I become a teacher in the future."

Question 4: What kind of negativities did you observe during the application of the questioning problem solving?

According to the results, responses were loaded into two loaded into themes. These themes and examples of related responses were given as following;

- Problems were difficult, (n=9)

  "Some problems occurred difficult to me".
  "Some problems were difficult for me."

- The discussions for problem solution took too long, (n=5)

  "The noise caused by the problem discussion sessions were long."
  "Sometimes we discussed a problem too much."

4.5. Summary of the Results

The following results obtained from the present study could be summarized as follows summarized under each measuring tool and type of analysis

- According to the results related to BMAT and MPST , the EG had the higher scores after treatment comparing the CG.
- The EG group was better in terms of gain score obtained in the sub- scales of motivation scale of MSLQ as IGO, EGO, TV, COLB, SELB and TA.
- Overall mean scores of EG in the learning strategies; REH, ELA, ORG, CT, META, TSEM, PL, HS the EG had the higher scores comparing the CG.
- There was a statistically significant effect of different problem solving approach on the collective dependent variables of the pre-service teachers' scores on PostBMAT and PostMPST when their the PreBMAT scores and the PreMPST scores are controlled.
- There was a statistically significant mean difference for the PostBMAT between groups in the favor of questioning problem solving approach.
- There was a statistically significant mean difference for the PostMPST

between groups in the favor of questioning problem solving approach.

- There was significant overall effect of different problem solving approach on the collective dependent variables PostIGO, PostEGO, PostTV, PostCOLB, PostSELB, PostTA when the pre-test scores of IGO, EGO, TV, COLB, SELB and TA were controlled.
- There is a statistically significant mean difference for posttsest scores of TV between groups in the favor of questioning problem solving approach.
- There is a statistically significant mean difference for posttsest scores of COLB between groups in the favor of questioning problem solving approach.
- There is a statistically significant overall effect of different problem solving approach on the collective dependent variables of the PostREH, PostELA, PostORG, PostCT, PostMETA, PostTSEM, PostER, PostPL and PostHS when pretest scores of these variables were controlled.
- There was a a statistically significant mean difference for posttsest scores of META between groups in the favor of questioning problem solving approach.
- There was a statistically significant mean difference for the PostER between groups in the favor of questioning problem solving approach.
- According to the results of interviews; before the treatment all students had skills in Polya's understanding and making a plan phases. None of the students checked their solutions. However at the end of the treatment all students performed all of the phases.
- According to their opinions; the problem were required reasoning and enabled them to think differently and to understand the content better. Moreover, students about the positive behaviors brought by the questioning problem solving approach were that their individual attempts to solve problems improved their skills and then they have learned new ways of solution through class discussions. Moreover this approach enabled them to think differently.

CHAPTER 5

DISCUSSIONS, CONCLUSIONS AND IMPLICATIONS

In this chapter firstly discussion of results is summarized then internal validity and external validity are stated in the second section. Conclusions and implementations are given in the third section respectively. Implications are presented in the fourth section. Finally, recommendations for further research studies are given in the last section.

5.1 Discussion of the Study

The main purpose of this study was to investigate the effect of questioning problem solving approach on pre-service teachers' basic mathematics achievement, problem solving performance and their perceived motivation; intrinsic goal orientation, extrinsic goal orientation, task value, control of learning beliefs, self-efficacy for learning and performance, test anxiety and perceived use of learning strategies; rehearsal, elaboration, organization, critical thinking, metacognitive self-regulation, time and study environment, effort regulation, peer learning and help seeking. Questioning problem solving approach was implemented as an instruction to first grade elementary school pre-service teachers and analyzed whether there was an advance on basic mathematics achievement, problem solving performance and their self- regulated learning. As a result of the present study, at the end of the experimental process, a significant difference between the groups who exposed to the instruction of experimental approach and those who were not, in terms of achievement, problem solving performace and self regulated learning was found.

Initially, the result of first research question revealed that approximately 27% of the total variance of MANCOVA model for the collective dependent variables of the PostBMAT and PostMPST was explained by group membership. The treatment ES measured here approximately matched the large effect size.

Therefore, the results of this study are of practical significance. The results of this study, provide an evidence for conducting similar studies with different samples and topics.

In comparing the results of this research with those of the previous studies about problem solving this research supports the some findings of previous studies.

This conclusion supports the former studies (e.g. Verschaffel et al., 1999) which maintain that there is an attempt to learn and to develop problem solving skills at different and similar levels, and problem solving performence can be increased through instruction. Higgins (1997) presented that the sixth and seventh grade students who had been given the teaching of problem solving have gained positive attitudes. Verschaffel et al. (1999) have found that the teaching of problem solving given to the fourth and fifth grade students has helped them in solving mathematical application problems and students have become able to learn problem solving strategies.

Also it was observed that there was a meaningful difference between the students in the experimental group and control group in terms of the problem solving performance level. This finding proves that problem solving in social constructivist learning environment has a distinctive impact on increasing the problem solving achievement levels of students supporting the studies conducted by De Corte (2004). Charles & Lester (1985) found that children can learn how and when to use problem-solving strategies to successfully solve problems when provided with explicit instruction on the strategies. According the qualitative data pre-service teachers learnt to verify their solutions or they tried to use looking back or checking strategies. Thus former studies reported that problem solving strategies can be learnt (e.g.Verschaffel et al., 1999, Charles & Lester, 1985) and this study confirmed that.

Additionally according to the second research question of this study, it has documented that questioning problem solving approach versus traditional approach did make a significant influence on the collective variables of motivational strategy components as; intrinsic goal orientation, extrinsic goal orientation, task value, control of learning beliefs, self-efficacy for learning and performance, test anxiety. The results revealed that, 22% of the total variance of MANCOVA model for the collective dependent variables of the PostIGO, Post EGO, PostTV, PostCOLB, PostSELB, PostTA was explained by group membership. More over, according to the follow-up analyses it was found that questioning problem solving approach had positive influence on students' task value and control of learning beliefs. Students tend to participate in a task because of their interests and utilities.. These findings were revealed by both the statistical analysis and students' opinions. The researcher couldn't find a very paralel research studying the effect of problem solving approach that defined in this study on students' perceived motivation and use of learning strategies. Thus, this results may be explained by some aspects. Firstly the time duration of the implementation was ten weeks and the age of participants were between 18 and 20. So this time period may not be enough for an adult to make a change in her/his motivational believes.

With respect to the results of third research question, it was found that that questioning roblem solving approach did make a significant influence on the collective variables of learning strategy components such as; rehersal, elaboration, organisation, critical thinking, metacognitive self-regulation, time and study environment management, effort regulation, peer learning and help seeking. The results showed that, 35% of the total variance of MANCOVA model for the collective dependent variables of the post test scores of all sub components of learning strategies. Besides, from the results the follow-up analyses it can be concluded that problem solving approach enhances students' use of metacognitive self-regulation and effort regulation in the favor of experimental group. Mean scores of effort regulation in did not make an important change in experimental group' pre and post tests but mean score in control group decreased drastically so this negatively change made a significant difference between two groups. Thus, it can be infered that traditional problem solving approach did not developed effort regulation. On the contrary, it has affected negatively. More over, the follow-up analyses showed that questioning problem solving approach had positive influence on students' metacognitive self regulation. Metacognition and problem solving used in this study were relevant, because questioning problem-solving was applied to give students the opportunities for dealing with problem solving consistently, discussing their solution strategies and building up their own informal strategies for solving problems. They tried to find the solutions by themselves firstly and by the whole clasroom discussion they learned different problem solving strategies. Besides this, Polya's problem solving phases contains both cognitive and metacognitive process. Since questioning problem solving approach was basis on the Polya's problem solving framework, it affected students' metacognitive self regulation positively in experimental group.

The other result found from fourth research question showed that encouraging all the students in the questions regarding their own thinking processes during problem solving prompted to look back, in other words, check behaviours. It is extremely important that students learn to look back after engaging in problem solving. They should look back at the problem to see how it is similar to and different from others, look back the answers to make sure it is reasonable, look back the solution process whether they used the right strategy and most important look back at their own thinking at how they thought about the problem and why (Rey et al, 2007). Looking back or checking phase is related with metacognition. Thus this result was coincided the result that questioning problem solving approach affected students' metacognitive self regulation positively in experimental group. Besides this remarkable result was observed at the end of the research that students on low math success level have displayed the expected behaviours most in the problem.The high achiever students interviewed haven't exhibited a relatively remarkable change in the phases of understanding problem, planning and plan implementation. It is said that all the students interviewed have had understanding and planning skills at the beginning of the experimental study. When age levels of the students and their mathematical knowledge are taken into account this situation is quite usual.

According to the students' opinions about the treatment or questioning problem solving, they have mentioned that they have begun to think logically and understand that mathematics is not an abstract science. The common opinions among the students about the positive behaviors brought by the questioning problem solving were that their individual attempted to solve problems improved their skills and then they have learned new ways of solution through class discussions. In addition, they expressed that they have realized the importance of setting problem. They also stated that, since they learned this method by experiencing it, it is a good example for them as they will be teachers in the future, and they learned to look at mathematics from different angles. As mentioned earlier that the researcher pre-service teacher education is very crutial. Teachers in future need to develop their own problem–solving performance. Thus this implementation not only developed their problem-solving performance but also guided through the problem solving process.

As a conclusion the results revealed that, there was an increase in problem solving skills of the students who have been exposed to the intervention approach. For this reason, questioning problem solving approach can be used as a useful tool in order to develop the problem solving skills which is included among the primary objectives of mathematics education curricula and which plays an important role in the academic development of students (MoNE, 2005a). Accordingly it is suggested that, mathematical problem solving should be embedded in all mathematics course.

All students are expected to acquire sufficient mathematical problem solving skills so that they are well prepared for the majority of jobs in this century that require high levels of mathematical and technical skills. This study to serve as a basis for studies related to future and providing empirical evidence to designers of problem solving can utilize to improve problem solving skills.

For this reason, an application towards this aim during problem solving activities in schools will be useful for students. Present study supported that in mathematics course problem solving instruction improves mathematics achievement. Depending on the results for further studies, investigating the effect of qustioning problem solving with different group sizes, and at different grade levels in other mathematics courses suggested. Although many reform advocates have stressed the need for an increased focus on problem solving, many elementary school teachers continue to instruct problem solving in a traditional way. It may be possible to support teachers in their efforts to deliver the aim of our new mathematics program that includes emphasis in the areas of problem solving. Accordingly, preservice teacher education students need to be prepared to teach mathematics utilizing problem solving as both a pedagogical methodology and as a heuristic that should be actively taught to students. When these students decide to become teachers, they had an image formed in their minds about what a teacher was. That image was based upon their own experiences as students. At the end of the study, pre-service teachers realized teaching mathematics by problem solving no longer resembled the traditional image they had in their minds. Moreover, they realize that mathematic can be used in daily life more than use in shopping.

Finally, it can be said as a final though that, since problem solving is the main cornerstone of the mathematics education it was hoped that the experiences preservice teachers had in this mathematics course would teach them how to teach mathematics in the new way their problem solving skills and apprach to learning. “The important point about problem solving is not that some people are better at it than other. Instead, the important point is that problem solving can be learned. It frequently isn’t learned because it isn’t taught”(Bransford & Stein, 1993) (as cited in Baker, 1998)

5.2 Internal Validity and External Validities

Possible threats to the internal and external validities of this study and their control were discussed in this subsection.

5.2.1. Internal Validity

The internal validity of the study refers to the degree to which extraneous variables may influence the results of research (Fraenkel & Wallen, 2000). Possible threats to internal validity and the methods used to cope with them were discussed in this section.

In this study, subjects were not were randomly assigned, thus many subject characteristics (e.g, pretests scores, prior mathematical knowledge) may affect students' post tests scores. These variables can be regarded as potential extraneous variables of the study. All of these variables were included in the covariate set to statistically match subjects on these factors. The pretest scores of basic mathematics achievement test, mathematical problem performance test, sub scales of motivation and learning strategies were directly measured and were included in the covariate set, so possible .

For history effect, groups were administered all tests approximately at the same time. By this way similar situations were tried to be provided. The results of the treatment may be associated with specific events occurred between pretest and posttest. This will not be an issue because the length of the study.

Location threat was reduced by satisfying similar situations in group. The location was the same mathematics class. Situations for both groups were tried to be made similar and the tests were administered to all groups at the same class in order to alleviate location threat.

A Hawthorne effect and data collector characteristics should not be a threat to the study. Being exposing to a pretest might affect students' performance on the posttest. However, it is assumed that pretest affected both groups equally. The experiment duration of the study was totally 10 weeks, so time duration was long to memorize the items in pretest.

Confidentiality was not a problem in this study since characteristics and names of students were not be used in any form. Students' names were taken for the sake of statistical analysis, and only the researcher knew and could access to them.

An instrumentation threats could be in the form of instrument decay, data collector bias, or inadequate demonstration of reliability and validity of the assessment. In this study although an open-ended questions were used in the performance tests, each questions were divided into subtasks according to the objectives covered and each tasks were scored. Therefore, instrument decay was not a viable threat.

5.2.2. External Validity

Subjects of the study were not randomly selected from the accessible population. They were the students of one public university in Ankara. Generalization of this study's findings was limited due to use of a non random sample convenience. But, generalizations to similar populations of university students might have been accepted. So the results and conclusions found in the study can be applied to a broader target population. However, the results were presented in this study could be applied to a broader population of samples having similar characteristics with the sample of this study.

The research study was conducted in the same class.The sitting arrangements and the lighting were equal; therefore, the threats to the ecological validity were also controlled.

Treatments and all testing procedure took place in ordinary classrooms during regular class time. There were possibly no remarkable differences among the environmental conditions created by the instructors. Ecological validity was adequately controlled by the settings used in this study.

5.3 Conclusions of the Study

Internal and external validity threats of this experiment were sufficiently controlled by the settings of the study. Since the sample of the study chosen by the use of a nonrandom sample of convenience, the generalizability of this research was somewhat limited. The conclusions offered here can be applied to a broader population of similar universities department of elementary teacher education. The conclusions are in the followings.

Questining problem solving approach improved presevice teachers' basic mathematics achievement and problem solving performance, when mean scores of the experimental and control group were compared. Although, preservice teachers' BMAT and MPST scores were increased from pretest to the posttest in both experimental and control groups, the increase in experimental group was higher than the control group. So, this approach increased basic mathematics achievement and problem solving performance higher than the traditional method.

Preservice teachers' perceived task value, control of learning beliefs, self-efficacy for learning and performance self and test anxiety were increased from pretest to the posttest in experimental group. Their overall means of sub-components got higher after treatment except instrinsic and extrinsic goal oriantation. However, CG's scores on instrinsic and extrinsic goal oriantation, task value, control of learning beliefs, self-efficacy for learning and performance self and test axiety were decreased from pretest to the posttest. Thus, traditional problem solving approach caused an overall mean decrease on their perceieved motivation. As a conclusion questioning problem solving approach improved pre-service teaches' perceived control of learning beliefs and task value but had no effect on their perceived intrinsic goal orientation, extrinsic goal oriantation, self-efficacy for learning and performance and test anxiety when mean scores of the experimental and control group were compared statistically by controlling their perior perceived motivational strategies.

Additionally, questioning problem solving approach had no effect significantly on students' use of rehearsal, organization, elaboration strategies, critical thinking, management of their time and study environment, peer learning and help seeking, but this approach improved preservice teachers' use of metacognitive self-regulation strategies, and regulation of their effort when mean scores of the experimental and control group were compared statistically by controlling their perior perceived use of learning strategies.

The other conclusion was, all the students with questions regarding their own thinking processes during problem solving, triggers looking back. It is extremely important that students learn to look back after engaging in problem solving. Thus problem solving has increased students' problem solving performance specially to their verification behaviour in problem solving process.

When the responses of students are examined, they were in consensus that the problems were about the everyday life. Moreover, the problems enabled them to think reasonblyrethink. They perceived the problem solving to be very strange at the beginning, they had not seen such an approach before but eventually they got used to, and they found it very helpful for them. The common opinions among the students about the positive behaviors brought by the problem solving method were that their individual attempts to solve problems improved their skills and then they have learned new ways of solution through classroom discussions.They also stated that, since they learned this method by experiencing it, it is a good example for them as they will be teachers in the future, and they learned to look at mathematics from different angles.

5.4 Recommendations

Questioning problem solving can be used to develop pre-service teachers' problem solving performance and achievement at universities in basic mathematics course. This approach may not only improve preservice teachers' problem solving performance but also guide them in their teaching and their professional life.

Teacher traning programmes are crucial for obtaining information and becoming skillful at problem solving of the teachers. When the teacher's required characteristics in the "training-teaching efficiencies" are defined by MoNE(2005b) this situation can be better understood. It is reported in MoNE(2005b) that teacher should guide students to develop their own solution strategy and encourage students to be creative problem solver and regulated students' learning environment. Thus, questioning problem solving can prepare in-service training for the teachers. By this way, teachers can develop their pedagogical approaches and inform about implementation. Therefore , this way can help to improve their problem solving teaching efficiencies pointed at MoNE (2005b).

In this study, contents in basic mathematics course cover lots of mathematical subjects. A future research will focus on one mathematics content; for instance, only relation and function concept.

In this study, questioning approach is applied in basic mathematics course, another research can construct the application in a different mathematics course.

A retention study should be designed to examine whether student's achievement and problem solving performance would change or not after treatment.

Finally it can be deduced that questioning problem solving does make an essential differences on achievement, problem solving performance, perceived task value, control of learning beliefs, use of metacognitive, self regulation and effort regulation. However, a question leaves unanswered. It is that what long term advantages this type of instruction could provide. It is hoped that this question will be searched and a conclusion will be reached by means of further researhes.

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APPENDIX A

ÖGRENMEDE GÜDÜSEL STRATEJİLER ANKETİ

Değerli Öğrenciler,

Bu anket iki kısımdan oluşmaktadır. İlk kısımda matematik dersine karsı tutumunuzu, motivasyonunuzu, ikinci kısımda ise matematik dersinde kullandığınız öğrenme stratejileri ve çalışma becerilerini belirlemeye yönelik ifadeler yer almaktadır. Cevap verirken aşağıda verilen ölçeği göz önüne alınız. Eğer ifadenin sizi tam olarak yansıttığını düşünüyorsanız, 7' yi yuvarlak içine alınız Eğer ifadenin sizi hiç yansıtmadığını düşünüyorsanız, 1' yi yuvarlak içine alınız. Bu iki durum dışında ise 1 ve 7 arasında sizi en iyi tanımladığını düşündüğünüz numarayı yuvarlak içine alınız. Unutmayın **Doğru y**a da **Yanlış** cevap yoktur yapmanız gereken sizi en iyi tanımlayacak numarayı yuvarlak içine almanızdır.

1 --- 2 --- 3 --- 4 --- 5 --- 6 -- 7
beni hiç beni tam olarak
yansıtmıyor yansıtıyor

Lütfen bütün ifadeleri cevaplandırınız. Bu ankete verdiğiniz bütün bilgiler **gizli** tutulacak ve **yalnızca araştırmacı** tarafından kullanılacaktır. Aşağıda istenen kişisel bilgileriniz, anketin güvenilir olması için gerekmektedir. Araştırmaya katkılarınızdan dolayı çok teşekkür ederim.

	Beni hiç yansıtmıyor						**Beni tam olarak yansıtıyor**
1. Matematik dersinde yeni bilgiler öğrenebilmek için, büyük bir çaba gerektiren sınıf çalışmalarını tercih ederim.	1	2	3	4	5	6	7
2. Eğer uygun şekilde çalışırsam, matematik dersindeki konuları öğrenebilirim.	1	2	3	4	5	6	7

3. Matematik sınavları sırasında, diğer arkadaşlarıma göre soruları ne kadar iyi yanıtlayıp yanıtlayamadığımı düşünürüm	1	2	3	4	5	6	7
4. Matematik dersinde öğrendiklerimi başka derslerde de kullanabileceğimi düşünüyorum.	1	2	3	4	5	6	7
5. Matematik dersinden çok iyi bir not alacağımı düşünüyorum.	1	2	3	4	5	6	7
6. Matematik dersi ile ilgili okumalarda yer alan en zor konuyu bile anlayabileceğimden eminim.	1	2	3	4	5	6	7
7. Benim için su an matematik dersi ile ilgili en tatmin edici şey iyi bir not getirmektir	1	2	3	4	5	6	7
8. Matematik sınavları sırasında bir soru üzerinde uğraşırken, aklim sınavın diğer kısımlarında yer alan cevaplayamadığım sorularda olur	1	2	3	4	5	6	7
9. Matematik dersindeki konuları öğrenemezsem bu benim hatamdır.	1	2	3	4	5	6	7
10. Matematik dersindeki konuları öğrenmek benim için önemlidir	1	2	3	4	5	6	7
11. Genel not ortalamamı yükseltmek su an benim için en önemli şeydir, bu nedenle matematik dersindeki temel amacım iyi bir not getirmektir.	1	2	3	4	5	6	7
12. Matematik dersinde öğretilen temel kavramları öğrenebileceğimden eminim.	1	2	3	4	5	6	7
13. Eğer başarabilirsem, matematik dersinde sınıftaki pek çok öğrenciden daha iyi bir not getirmek isterim	1	2	3	4	5	6	7
14. Matematik sınavları sırasında bu dersten başarısız olmanın sonuçlarını aklımdan geçiririm	1	2	3	4	5	6	7
15. Matematik dersinde, öğretmenin anlattığı en karmaşık konuyu anlayabileceğimden eminim.	1	2	3	4	5	6	7
16. Matematik derslerinde öğrenmesi zor olsa bile, bende merak uyandıran sınıf çalışmalarını tercih ederim.	1	2	3	4	5	6	7
17. Matematik dersinin kapsamında yer alan konular çok ilgimi çekiyor.	1	2	3	4	5	6	7
18. Yeterince sıkı çalışırsam matematik dersinde başarılı olurum.	1	2	3	4	5	6	7
19. Matematik sınavlarında kendimi mutsuz ve huzursuz hissederim.	1	2	3	4	5	6	7

20. Matematik dersinde verilen sınav ve ödevleri en iyi şekilde yapabileceğimden eminim.	1	2	3	4	5	6	7
21. Matematik dersinde çok basarîli olacağımı umuyorum	1	2	3	4	5	6	7
22. Matematik dersinde beni en çok tatmin eden şey, konuları mümkün olduğunca iyi öğrenmeye çalışmaktır.	1	2	3	4	5	6	7
23. Matematik dersinde öğrendiklerimin benim için faydalı olduğunu düşünüyorum.	1	2	3	4	5	6	7
24. Matematik dersinde, iyi bir not getireceğimden emin olmasam bile öğrenmeme olanak sağlayacak ödevleri seçerim.	1	2	3	4	5	6	7
25. Matematik dersinde bir konuyu anlayamazsam bu yeterince sıkı çalışmadığım içindir.	1	2	3	4	5	6	7
26. Matematik dersindeki konulardan hoşlanıyorum.	1	2	3	4	5	6	7
27. Matematik dersindeki konuları anlamak benim için önemlidir.	1	2	3	4	5	6	7
28.Matematik sınavlarında kalbimin hızla attığını hissederim.	1	2	3	4	5	6	7
29.Matematik dersinde öğretilen becerileri iyice öğrenebileceğimden eminim.	1	2	3	4	5	6	7
30. Matematik dersinde başarılı olmak istiyorum çünkü yeteneğimi aileme, arkadaşlarıma göstermek benim için önemlidir.	1	2	3	4	5	6	7
31. Dersin zorluğu, öğretmen ve benim becerilerim göz önüne alındığında, matematik dersinde başarılı olacağımı düşünüyorum	1	2	3	4	5	6	7
B. Öğrenme Stratejileri							
32. Matematik dersi ile ilgili bir şeyler okurken, düşüncelerimi organize etmek için konuların ana baslıklarını çıkarırım.	1	2	3	4	5	6	7
33. Matematik dersi sırasında başka şeyler düşündüğüm için önemli kısımları sıklıkla kaçırırım.	1	2	3	4	5	6	7
34. Matematik dersine çalışırken çoğu kez arkadaşlarıma konuları açıklamaya çalışırım	1	2	3	4	5	6	7
35. Genelde, ödevlerime rahat konsantre olabileceğim bir yerde çalışırım.	1	2	3	4	5	6	7

36. Matematik dersi ile ilgili bir şeyler okurken, okuduklarıma odaklanabilmek için sorular oluştururum.	1	2	3	4	5	6	7
37. Matematik dersine çalışırken kendimi çoğu zaman o kadar isteksiz ya da o kadar sıkılmış hissederim ki, planladıklarımı tamamlamadan çalışmaktan vazgeçerim.	1	2	3	4	5	6	7
38. Matematik dersiyle ilgili duyduklarımı ya da okuduklarımı ne kadar gerçekçi olduklarına karar vermek için sıklıkla sorgularım.	1	2	3	4	5	6	7
39. Matematik dersine çalışırken, önemli bilgileri içimden defalarca tekrar ederim	1	2	3	4	5	6	7
40. Matematik dersinde bir konuyu anlamakta zorluk çeksem bile hiç kimseden yardım almaksızın kendi kendime çalışırım.	1	2	3	4	5	6	7
41. Matematik dersi ile ilgili bir şeyler okurken bir konuda kafam karışırsa, basa döner ve anlamak için çaba gösteririm.	1	2	3	4	5	6	7
42. Matematik dersine çalışırken, daha önce okuduklarımı ve aldığım notları gözden geçirir ve en önemli noktaları belirlemeye çalışırım.	1	2	3	4	5	6	7
43. Matematik dersine çalışmak için ayırdığım zamanı iyi değerlendirebiliyorum.	1	2	3	4	5	6	7
44.Eğer matematik dersi ile ilgili okumam gereken konuları anlamakta zorlanıyorsam, okuma stratejimi değiştiririm.	1	2	3	4	5	6	7
45. Matematik dersinde verilen ödevleri tamamlamak için sınıftaki diğer öğrencilerle çalışırım.	1	2	3	4	5	6	7
46. Matematik dersine çalışırken, dersle ilgili okumaları ve ders sırasında aldığım notları defalarca okurum	1	2	3	4	5	6	7
47. Ders sırasında veya ders için okuduğum bir kaynakta bir teori, yorum ya da sonuç ifade edilmiş ise, bunları destekleyen bir bulgunun var olup olmadığını sorgulamaya çalışırım.	1	2	3	4	5	6	7
48. Matematik dersinde yaptıklarımızdan hoşlanmasam bile başarılı olabilmek için sıkı çalışırım.	1	2	3	4	5	6	7
49. Dersle ilgili konuları organize etmek için basit grafik, sema ya da tablolar hazırlarım.	1	2	3	4	5	6	7

50. Matematik dersine çalışırken konuları sınıftaki arkadaşlarımla tartışmak için sıklıkla zaman ayırırım	1	2	3	4	5	6	7
51. Matematik dersinde islenen konuları bir başlangıç noktası olarak görür ve ilgili konular üzerinde kendi fikirlerimi oluşturmaya çalışırım.	1	2	3	4	5	6	7
52. Çalışma planına bağlı kalmak benim için zordur.	1	2	3	4	5	6	7
53. Matematik dersine çalışırken, dersten, okuduklarımdan, sınıf içi tartışmalardan ve diğer kaynaklardan edindiğim bilgileri bir araya getiririm.	1	2	3	4	5	6	7
54. Yeni bir konuyu detaylı bir şekilde çalışmaya başlamadan önce çoğu kez konunun nasıl organize edildiğini anlamak için ilk olarak konuyu hızlıca gözden geçiririm.	1	2	3	4	5	6	7
55. Matematik dersinde islenen konuları anladığımdan emin olabilmek için kendi kendime sorular sorarım.	1	2	3	4	5	6	7
56. Çalışma tarzımı, dersin gereklilikleri ve öğretmenin öğretme stiline uygun olacak tarzda değiştirmeye çalışırım.	1	2	3	4	5	6	7
57. Genelde derse gelmeden önce konuyla ilgili bir şeyler okurum fakat okuduklarımı çoğunlukla anlamam	1	2	3	4	5	6	7
58. İyi anlamadığım bir konuyu öğretmenimden açıklamasını isterim.	1	2	3	4	5	6	7
59.Matematik dersindeki önemli kavramları hatırlamak için anahtar kelimeleri ezberlerim.	1	2	3	4	5	6	7
60. Eğer bir konu zorsa ya çalışmaktan vazgeçerim ya da yalnızca kolay kısımlarını çalışırım	1	2	3	4	5	6	7
61. Matematik dersine çalışırken, konuları sadece okuyup geçmek yerine ne öğrenmem gerektiği konusunda düşünmeye çalışırım.	1	2	3	4	5	6	7
62. Mümkün olduğunca matematik dersinde öğrendiklerimle diğer derslerde öğrendiklerim arasında bağlantı kurmaya çalışırım.	1	2	3	4	5	6	7
63. Matematik dersine çalışırken notlarımı gözden geçirir ve önemli kavramların bir listesini çıkarırım.	1	2	3	4	5	6	7

64. Matematik dersi için bir şeyler okurken, o anda okuduklarımla daha önceki bilgilerim arasında bağlantı kurmaya çalışırım.	1	2	3	4	5	6	7
65. Ders çalışmak için devamlı kullandığım bir yer (oda vs.) vardır	1	2	3	4	5	6	7
66. Matematik dersinde öğrendiklerimle ilgili ortaya çıkan fikirlerimi sürekli olarak gözden geçiremeye çalışırım.	1	2	3	4	5	6	7
67. Matematik dersine çalışırken, dersle ilgili okuduklarımı ve derste aldığım notları inceleyerek önemli noktaların özetini çıkarırım.	1	2	3	4	5	6	7
68. Matematik dersinde bir konuyu anlayamazsam sınıftaki başka bir öğrenciden yardım isterim.	1	2	3	4	5	6	7
69. Matematik dersiyle ilgili konuları, ders sırasında öğrendiklerim ve okuduklarım arasında bağlantılar kurarak anlamaya çalışırım.	1	2	3	4	5	6	7
70. Matematik derslerinde verilen ödevleri ve derse ilgili okumaları zamanında yaparım.	1	2	3	4	5	6	7
71. Matematik dersindeki konularla ilgili bir iddia ya da varılan bir sonucu her okuduğumda veya duyduğumda olası alternatifler üzerinde düşünürüm	1	2	3	4	5	6	7
72. Matematik dersinde önemli kavramların listesini çıkarır ve bu listeyi ezberlerim.	1	2	3	4	5	6	7
73. Matematik derslerini düzenli olarak takip ederim	1	2	3	4	5	6	7
74. Konu çok sıkıcı olsa da, ilgimi çekmese de konuyu bitirene kadar çalışmaya devam ederim.	1	2	3	4	5	6	7
75. Gerektiğinde yardım isteyebileceğim arkadaşlarımı belirlemeye çalışırım.	1	2	3	4	5	6	7
76. Matematik dersine çalışırken iyi anlamadığım kavramları belirlemeye çalışırım.	1	2	3	4	5	6	7
77. Başka faaliyetlerle uğraştığım için çoğu zaman matematik dersine yeterince zaman ayıramıyorum	1	2	3	4	5	6	7
78. Matematik dersine çalışırken, çalışmalarımı yönlendirebilmek için kendime hedefler belirlerim.	1	2	3	4	5	6	7
79. Ders sırasında not alırken kafam karışırsa, notlarımı dersten sonra düzenlerim.	1	2	3	4	5	6	7

80. Matematik sınavından önce notlarımı ya da okuduklarımı gözden geçirmek için fazla zaman bulamam.	1	2	3	4	5	6	7
81. Matematik dersinde, okuduklarımdan edindiğim fikirleri sınıf içi tartışma gibi çeşitli faaliyetlerde kullanmaya çalışırım.	1	2	3	4	5	6	7

APPENDIX B

MATEMATİKSEL PROBLEM ÇÖZME TESTİ

Adınız Soyadınız:
Numaranız:
Şubeniz:

PROBLEM 1:

Bir otobüsün sabit hızla hareket ederken a saat sonunda deposundaki yakıt miktarı
M=75-5a denklemiyle verilmektedir. Depodaki yakıt miktarı 10 litrenin altına düşünce otobüsün yakıt alması gerekmektedir. Sabit hızla hareket halinde olan bir otobüsün en erken kaçıncı saate yakıt alması gerekmektedir.
Çözüm:

PROBLEM 2:

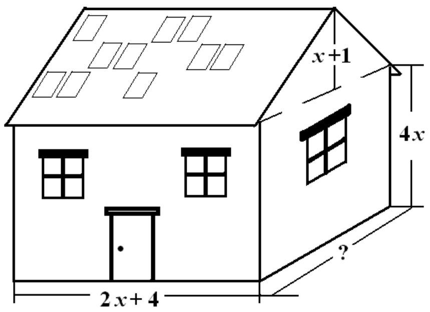
Çiftçi Ahmet Bey, hobi olarak çiftliğinde tavşan beslemektedir. Nisan ayı boyunca tavşanların sayısı % 10 arttı. Mayıs ta 10 yeni tavsan daha oldu ve Ahmet Bey tavşanların üçte birini sattı. Haziran boyunca 20 yeni tavşan daha oldu ve Haziran sonunda tavşanların yarısını daha sattı. Temmuz ayında doğan 5 tavşanla tavşanların sayısı 55 e ulaştı. Ahmet Beyin Nisan ayının basında aldığı tavsan sayısı nedir?
Çözüm:

PROBLEM 3:

A ilçesinin 6800 olan nüfusu her yıl ortalama 120 kişi azalmaktadır. B ilçesinin ise 4200 olan nüfusu ortalama yılda 80 kişiyle artış göstermektedir. Kaç yıl sonra bu iki ilçenin nüfusu aynı olur?
Çözüm:

PROBLEM 4:

Şekildeki çocuklar için yapılmış oyun evinin toplam hacmi
$9x^3 + 46x^2 + 59x + 6$ m^3 dır. Evin gövdesinin eni 2x+4, gövde yüksekliği 4x, çatısının yüksekliği x+1 ise oyuncak evin verilmeyen boyutunu bulunuz.



Çözüm:

PROBLEM 5:

Dikdörtgen şeklindeki bir kartonun köşelerinden kenar uzunluğu 2 cm olan kareler kesilerek üstü açık bir dikdörtgen prizma yapılacaktır. Dikdörtgen şeklindeki kartonun kenar uzunlukları x ve y olmak üzere $x + y = 15$ cm dır . Dikdörtgen prizmanın hacmi 24 cm^3 ise x ve y nedir.

Çözüm:

PROBLEM 6:
Aşağıdaki ifadelerden yansıyan, simetrik ve geçişme özelliklerinden hangilerini sağlar nedenleriyle açıklayınız.

“aynı yaşta olmak”

“aynı soyadını taşıma”
“evli olmak”
“ebeveyn olmak”
“büyük olmak”

Çözüm:

PROBLEM 7: Diyet ürünlerinde rastlanabilen aspardam(tatlandırıcı) şekerden daha tatlıdır. 10 çay kaşığı şeker, bir çay kaşığının 20 de biri kadar aspardam ile eşdeğerdir.
Seker ile aspardam arasındaki ilişki bir fonksiyon belirtir mi? Cevabınızı savununuz.

Çözüm:

PROBLEM 8:

Tabloda boş bırakılan yerleri doldurunuz

F(x)	**G(x)**	**Fog(x)**
(x+1)	----	x
x^2	x+1	---
---	x-1	$1/ x^2$

Çözüm:

PROBLEM 9:

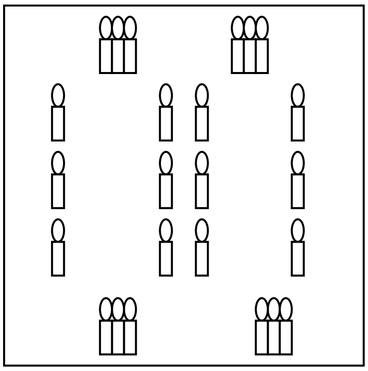
f : [-1, 100) → IR olsun. Bu aralıkta x’in küpüyle orantılı olan bir birebir fonksiyon yazınız. Bu fonksiyonun neden birebir olduğunu açıklayınız.

Çözüm:

PROBLEM 10:

İdil in annesi ona doğum gününde 12cmx 12 cm x 5 cm ebatlarında bir doğum günü pastası hazırladı. Doğum gününe 10 kişi katılmıştır. İdil pastayı eşit olarak kestiğine göre her bir kişiye ne kadar pasta düşer.
Çözüm:

PROBLEM 11:
Bir çiftçi kare biçimindeki tarlasına 24 tane ağaç dikti. 8 oğluna eşit t sayıda ağaç ve eşit alanda tarla miras bırakmak istiyor. Tarlayı nasıl bölmelidir?



PROBLEM 12: Aşağıdaki haritada görüldüğü gibi Bolu, Gerede ve Mengen'e eşit uzaklıkta olacak bir noktaya havaalanı yapılmak istenmektedir. Eğer Bolu-Gerede arası 50 km, Bolu-Mengen arası (kuş uçumu) 40km ve Gerede-Mengen arası 30km ise havaalanı için en uygun noktayı bulunuz.

Mengen

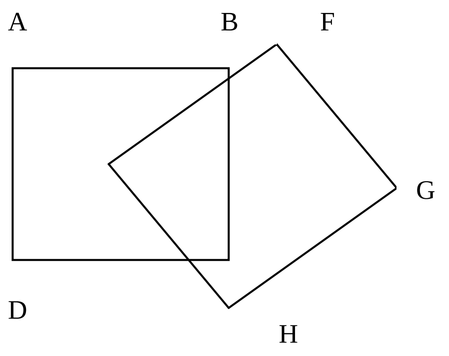
Bolu

Gerede

Çözüm:

Problem 13:

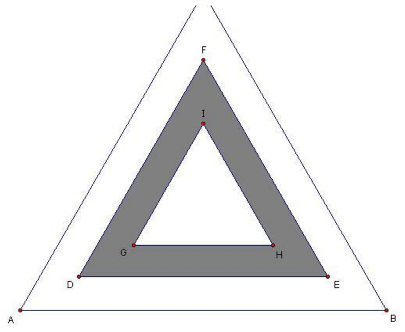
Kenar uzunlukları 8 cm olan kareler şekildeki gibi birinin köşesi diğerinin merkezine gelecek şekilde yerleştirilmiştir. İki kare arasında kalan bölgenin alanı nedir?



Çözüm:

Problem 14:

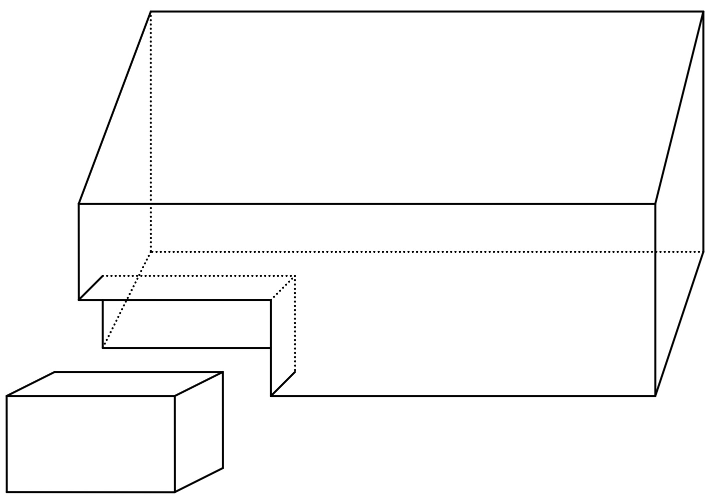
Şekildeki ABC, DEF ve GHI üçgenlerinin kenarları
birbirlerine paralel ve 1 birim uzaklıktadır. DEF üçgeni
ABC ile GHI
Üçgenlerinin ortasında yer almaktadır.
|DF| = 5 birim, |FE|= 6 birim, |ED|= 7
Olduğuna göre A(ABC)- A(GHI) nedir?



Çözüm:

Problem 15:

"Boyutları 6 cm, 8cm ve 12 cm olan dikdörtgen prizması
şeklindeki tahtanın bir köşesinden yukarıda gösterildiği gibi
dikdörtgen prizması şeklindeki küçük parça çıkartılıyor.
Büyük parçanın alanı kaç santimetre karedir?"
Problemin çözümü için ne söyleyebilirsiniz?



ROBLEM 16:

Bir cep telefonu operatörünün 2 farklı tarifesini gösteren tablolar aşağıda verilmiştir.

1. Tarife

Konuşma süresi (dakika)	1	2	3	…	…	n
Ücret (YTL)	0,9	1,8	2,7	…	…	

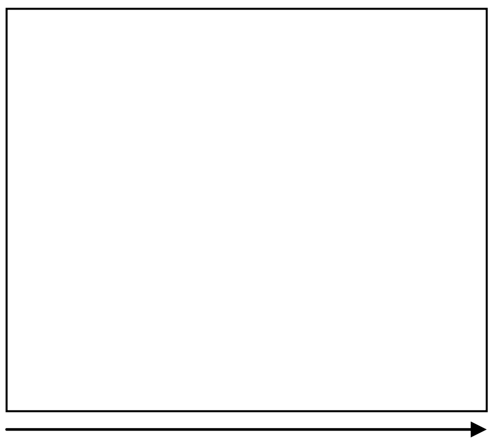
2. Tarife

Konuşma süresi (dakika)	0	1	2	3	…	m
Ücret (YTL)	9	9,3	9,6	9,9	…	

Her gün en az 30 dakika konuşan birisi için hangi tarife daha uygundur?

Çözüm :

PROBLEM 17: Dikdörtgen biçimindeki bir kümesin çevresi 22 metrelik tel örgü ile çevrilmiştir. Kümesin sahibi kümesin uzunluğu ile kümesin alanı arasında nasıl bir ilişki olduğunu bulmak istiyor. Kümesin uzunluğu ile kümenin alanı arasındaki ilişki nedir?



Kümesin uzunluğu; L

APPENDIX C

TEMEL MATEMATİK II BAŞARI TESTİ

Adınız Soyadınız:

Numaranız:
Şubeniz:

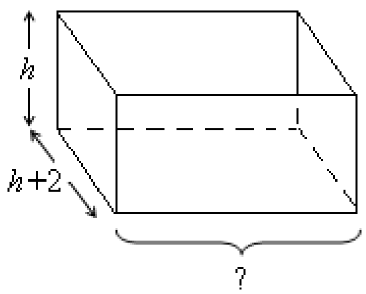
SORU 1: Plüton dünyamıza en uzak gezegendir. Aşağıdaki tablo Dünyamız ile Plüton 'un ağırlığını aynı birim cinsinden verdiğine göre, D' nin P ye bağlı denklemini yazınız.

Dünya (D)	1	2	3	4	5	10	100
Plüton(P)	0,04	0,08	0,12	0,16	0,20	0,40	4

Çözüm:

SORU 2: Şekildeki gibi bir kargo kutusunun hacmi $h^3 + 5h^2 + 6h$ m^3 tür. Kutunun yüksekliği h ve eni $h+2$ olduğuna göre kutunun uzunluğunu bulunuz.

Çözüm:



SORU 3: Aşağıdaki ifadeyi en sade biçimde yazınız.

$$\frac{a^3-27b^3}{a^3+3a^2b+9ab^2} \bullet \frac{a^3+3a^2b}{a^2-9b^2}$$

Çözüm:

SORU4: $(x^2-4)(x^2+2x) > 0$ eşitsizliğinin çözüm kümesini bulunuz.
Çözüm:

SORU 5: A = { 1, 2, 3, 4, 5 }kümesinde tanımlı
μ = { (2,2), (2,3), (3,2), (3,3), (4,4), (5,5),(1,5) }bağıntısının yansıma, geçişme, simetri ve ters simetri özelliklerini sağlayıp sağlamadığını nedenleriyle açıklayınız.

Çözüm:

SORU 6 : $\beta = \{ (x,y); x,y \in IR, y= x^2 \}$

$\mu = \{ (x,y); x,y \in IR, y= x^3 \}$

bağıntıları birer fonksiyon belirtir mi? Nedenleri ile açıklayınız.

Çözüm:

SORU 7: f ve g R de tanımlı olsun.

f: x ⟶ $y=\sqrt{x-2}$ g: x ⟶ y = x+1

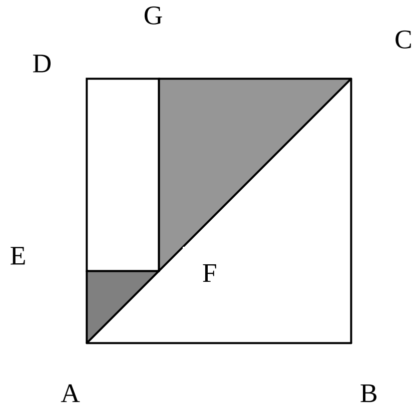
(gof)(x) bileşke fonksiyonunu yazabilir miyiz? Eğer yazabilirsek nedenleriyle açıklayınız.

Bu fonksiyonun tanım kümesini ve görüntü kümesini bulunuz.

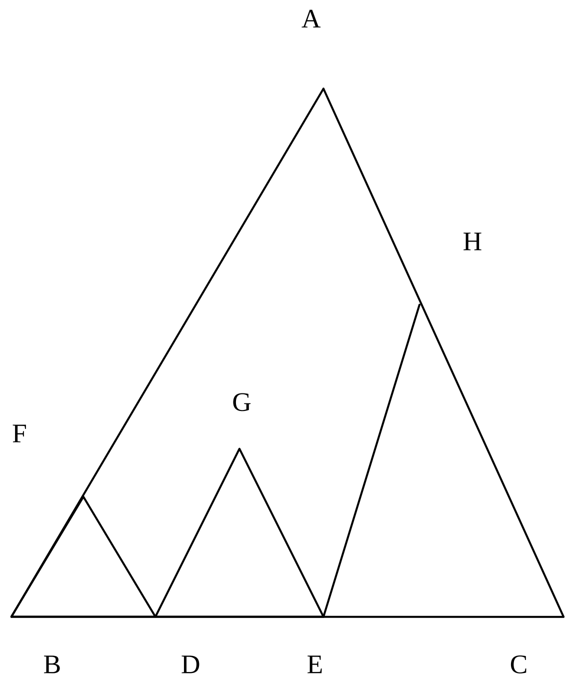
Çözüm:

SORU 8: $f(x) = -2(x-4)^2+2$ fonksiyonunun grafiğini çiziniz.
Çözüm:

SORU 9: Bir kenarı 12 cm olan ABCD Karesinin içine, bir kenarının uzunluğu diğer kenarın 3 katı olan şekildeki DEFG dikdörtgeni çiziliyor. Şekildeki taralı bölgelerin alanları toplamı nedir?

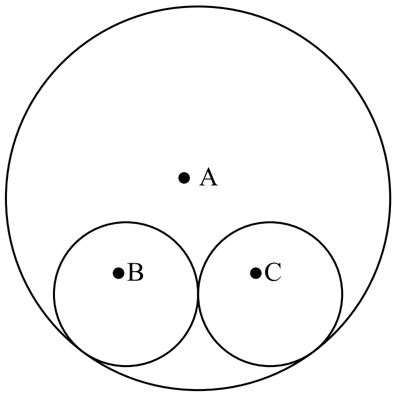


SORU 10: Şekilde verilen ABC eşkenar üçgeninin BC kenarı üzerinde, 4|BD|=2|DE| = |EC| uzunlukları çizilerek FBD, GDE ve HEC **eşkenar üçgenleri** elde ediliyor. ABC üçgeninin alanının FDGEHA kapalı bölgesinin alanına oranı nedir

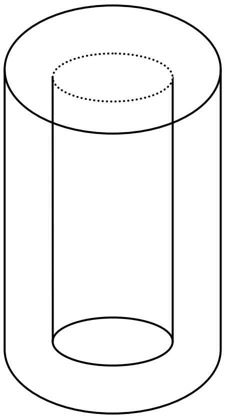


Çözüm:

SORU 11: Şekildeki A, B, C merkezli çemberler ikişer ikişer birbirine teğettir. Merkezleri B ve C olan çemberler birbirlerin eş çemberlerdir. ABC üçgeni; A, B ve C noktaları birleştiğinde eşkenar üçgen oluşturabilmesi için, büyük çemberin yarıçapı, küçük çemberin yarıçapının kaç katıdır olmalıdır?



SORU 12. Bir usta, yarıçapı 10 cm, yüksekliği 20 cm olan silindir şeklindeki kütüğün içinden şekildeki gibi yarıçapı 9 cm, yüksekliği 20 cm olan silindir şeklindeki parçayı çıkarıyor. Kalan silindir şeklindeki parçanın bütün yüzeyleri boyanacağına göre, boyanması gereken alan kaç santimetre karedir



Çözüm:

APPENDIX D

YARI YAPILANDIRILMIS GÖRÜŞME SORULARI

Yarı yapılandırılmış görüşmeler sırasında yönlendirilenen sorular;

1. Problem ne ile ilgili? Problemde bilinmeyen nedir?
2. Problemi daha iyi anlamak için nasıl bir yol izledin?
3. Problemi çözmek için ne yaptın?
4. Problemi çözmek için bir plan yaptın mı? Nasıl bir plan yaptın?
5. Çözümün doğruluğundan ve kullandığın stratejinin kullanışlı olduğunda emin misin?
6. Problemi çözmek için başka bir yol bulabilir misin?
7. Problemi çözerken seni çözüme götürmeyen bir yol denedin mi? Nasıl bu yolun yanlış olduğuna karar verdin?

Yarı yapılandırılmış görüşmeler sırasında sorulan problemler;

P1: Murat kütüphaneden aldığı 5 ödünç kitabı vermekte gecikiyor. Gecikmiş her kitabın günlük cezası 1YTL dir. Murat, birdenbire Astronomi kitabını diğer dört roman kitabından 7 gün önce kütüphaneden aldığını hatırlıyor. Murat'ın kütüphaneye ödemesi gereken toplam ceza 22 YTL olduğuna göre herbir kitap için kaç günlük ceza ödeyeceğini bulunuz.

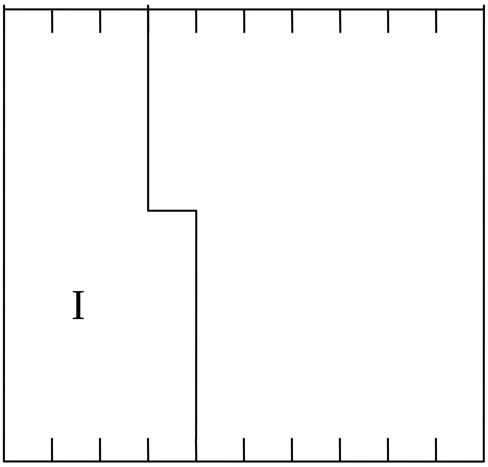
P2: Aşağıdaki tablo normal koşullar altında ortalama nabız sayısının(dakikada) yaşlara göre dağılımını vermektedir. Ali ve İdil 15 yasında olduklarına gore, nabız sayıları ortalamaları ne olur?

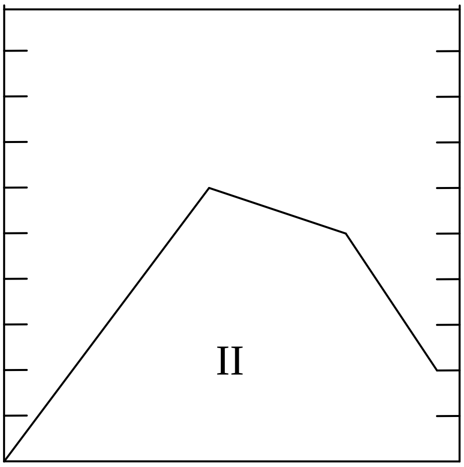
Yaş	10	20	30	40	50
Nabız sayısı	152	144	136	128	120

P3. Arkeologlar bir insanın uzunluğunu femurun uzunluğundan belirlemektedirler. Bunun için U = 2,3 F + 61,4 formülünü kullanmaktadırlar. Bir arkeolog 45 cm uzunluğunda bir insan femuru bulmuştur. Bu insan öldüğünde boyu ne kadardı?Bu ilişki bir fonksiyon olurmu? Nedenleriyle anlatınız?

P4. Bir basketbol liginde 6 takım yer almaktadır. Bunlar; aslanlar, kaplanlar, çelik spor, boğalar, çelik gövdeler ve güçlü spor takımlarıdır. Her takım diğer takımla 4 kere maç yapacağına göre, kaç oyun düzenlenmelidir?

P5. Aşağıdaki eş kareler I ve II. bölgelerine şekildeki gibi ayrılmıştır.
I ve II. bölgeleri yaklaşık olarak olarak tüm alanın kaçta kaçıdır?





P6. Polat ailesi yeni bir eve taşınmıştır. Aldıkları evin dış kapısı, 2,20 m x 1,20 m dir. Çapı 2,20 metre olan daire biçimindeki bir aynayı taşınma sırasında bu kapıdan içeri gecirebilirlermi? Neden?

APPENDIX E

OBSERVATION CHECKLIST

Sayın Araştırmacı,

İlköğretim sınıf öğretmenliği lisans programı Temel Matematik II dersini gözlemci olarak bulunmaktasınız. Deney grubunda problem çözme metodunun kullanıldığı, kontrol gruplarında ise geleneksel ders anlatma yönteminin kullanıldığından emin olmak için işlenen derslerle ilgili olarak aşağıdaki tabloyu hem deneysel hem de kontrol grupları için doldurunuz. Tabloyu doldururken sorulara vereceğiniz ve uygulamanın sınıf içersinde nasıl yapıldığını ifade edecek olan cevabınızı "birden yediye kadar ", derecelendirerek veya "yapılmadı" şeklinde ifade etmeniz gerekmektedir. Lütfen tüm kriterler için cevaplarınızı sağ taraftaki sütunda ilgili seçenekten 1 tanesini (X) şeklinde işaretleyerek belirtiniz.

Gözlem Listesi									Yapılmadı
		1	2	3	4	5	6	7	
1	Dersin işlenişi sırasında konuyla ilgili problem kâğıtları öğrencilere dağıtıldı.								
2	Problemi çözmeleri için öğrencilere vakit verildi.								
3	Öğretmen problemi önce bireysel çözmeleri için öğrencilere uyarıda bulundu.								
4	Öğretmen problemi okuyarak anlaşılmayan bir yer olup olmadığını sordu.								
5	Öğretmen problemde ne istendiğini sordu.								
6	Problemde anlaşılmayan noktalar için açıklamalar yapıldı.								

7	Öğretmen verilen süre bitiminde öğrencilerin isterlerse sınıftan herhangi bir öğrenciden, kendisinden ya da ipucu kartlarından yardım alabilecekleri ile ilgili uyarıda bulundu.								
8	Problem çözme aşamasında, problemi çözen öğrencilere çözümlerinden emin olup olmadıklarını emin değilseler tekrar kontrol etmeleri için uyarıda bulundu.								
9	Öğrencilerin problem çözme aşamasında sınıf ortamı sessiz ve sakindi.								
10	Öğrencilerin yardım alma sürecinde sınıf içinde rahatça dolaşmalarına izin verdi.								
11	Öğretmenin hazırladığı ipucu kartları masasını üzerinde öğrencilerin rahatça alabilecekleri şekilde hazırlanmıştı.								
12	Yardım alma sürecinde sonuca ulaşamayan öğrencilerin problem çözme basamaklarını yeniden kontrol etmeleri için uyarıda bulundu.								
13	Yardım alma süresi bittiğinde öğretmen problem çözme sürecini bittiğini söyledi.								
14	Problemin sınıfça tartışılma aşamasında söz isteyen her öğrenciye söz hakkı verildi.								
15	Problemi farklı stratejiler kullanılarak çözmüş öğrenciler tahtada problemi çözdü.								
16	Farklı çözüm yolları, problem stratejileri sınıfça tartışıldı.								
17	Öğrenciler kendi çözüm yollarını anlatırken, diğer arkadaşları onları dinledi.								
18	Öğrenciler birbirlerinin çözüm yollarına saygı gösterdiler.								
19	Öğretmen öğrencilere eşit davrandı.								
20	Öğretmen yönlendirici ve tartışma açıcı şekilde davrandı.								
21	Öğretmen derse katılımı artırmak için öğrencilere ayrı ayrı soru sordu.								

22	Öğretmen söz alıp konuşmak isteyenlere olanak tanıdı.								
23	Öğretmen yoklama aldı.								
24	Öğrencilerin derse katılımı nasıldı?								
25	Öğretmen ile öğrencilerin ilişkisi samimiyet ve saygı açısından nasıldı?								
26	Sınıfın sıcaklığı dersin işlenmesi için uygun muydu?								
27	Sınıftaki sıraların düzeni, yapısı ve sayısı dersin işlenmesi açısından nasıldı?								
28	Yan sınıflardan gelen gürültü ve sınıfın bulunduğu bina çevresindeki ses düzeyi dersin işlenmesi için uygun muydu?								
29	Sınıfın aydınlatılması ve ışık miktarı dersin işlenmesi için uygun mu?								
30	Ders günü sıradan normal bir ders gününden farklı olarak herhangi öneme sahip (kurtuluş günü, bayram, şenlik vb.) bir gün müydü? Bu açıdan dersin işlenmesi için uygun muydu?								
31	Dersin işlenişi sırasında tanımlar, gerekli teoremler öğretmen tarafından tahtaya yazıldı.								
32	Konu bitimlerinde alıştırma soruları çözüldü.								
Eklemek istedikleriniz:									

APPENDIX F

ÖĞRETİM METODUNU DEĞERLENDİRME FORMU

Ad Soyad:

Bu form dönem boyunca Temel Matematik I dersi içinde uyguladığımız problem çözme metoduna ilişkin görüşlerinizi belirlemek için hazırlanmıştır. Sizin görüşleriniz, bu öğretim metodunun daha etkili bir şekilde uygulanabilmesi açısından oldukça önemlidir.

Çalışmaya vereceğiniz katkılardan dolayı çok teşekkür ederim.

1. Dönem boyunca derste çözülen problemler ilgili görüşleriniz nelerdir?

2. Dönem boyunca Temel Matematik I dersi içinde uygulanan problem çözme metodu ile ilgili görüşleriniz nelerdir? Lütfen detaylı bir biçimde açıklayınız.

3. Problem çözme metodunun sizde olumlu etkiler bıraktığını düşünüyormusunuz? Cevabını evet ise metodun olumlu etkilerini deyatlı şekilde açıklayınız.

4. Problem çözme metodunun işlenişi sırasında olumsuzluklar gözlemlediniz mi? Lütfen detaylı bir biçimde açıklayınız.

Eklemek istedikleriniz:

APPENDIX G

PROBLEM ÇÖZÜMÜNÜN DEĞERLENDİRİLMESİ İÇİN BÜTÜNCÜL DERECELEME ÖLÇEĞİ

Durumu Açıklayan Maddeler	Puan
• Tamamen boş bırakılmış ya da yalnız veriler yazılmış, çözüm içim hiçbir girişim yok. • Yanlış bir yanıt var, yapılanlar yanlış bir düşünme sürecini işaret ediyor.	0
• Doğru bir stratejinin göstergeleri var ama uygulanmamış. • Hedefe ulaşmamış, ne olduğu pek de belli olmayan bazı matematikel çalışmalar var ama bir sonuç ortaya koyamamış. • Doğru yanıtı bulmuş ama yazdıklarından yanlış bir akıl yürütme yapmış olduğu anlaşılıyor.	1
• Doğru stratejiyi bulmuş ama uygulayamamış, yeterince uğraşmamış. • Doğru yanıtı bulmuş ama nasıl bulduğuna ilişkin bir gösterge yok. Yaptıklarına bakarak bir yorum yapılamıyor.	2
• Doğru stratejiyi bulmuş, uygulamış ama hesaplama hataları ya da kavram yanılgıları nedeniyle doğru yanıta ulaşamamış. • Doğru stratejiyi bulmuş, uygulamış ama kavram yanılgıları nedeniyle doğru yanıta ulaşamamış. • Doğru stratejiyi bulmuş, uygulama sırasında bazı hatalar görülüyor, ancak yine de doğru yanıta ulaşmış.	3
• Doğru stratejiyi bulmuş, doğru uygulamış ama problemi yazarken verilerden birini ya da birkaçını yanlış değerlendirdiğinden doğru sonuca ulaşamamış.	4
• Tam ve uygun bir çözüm, doğru bir sonuç var.	5

APPENDIX G

PROBLEMS USED IN LESSONS

1. A liginde 6 takım B liginde 5 tane takım varsa ve ligdeki her takım diğer takımla sadece 1 kere maça çıkarsa, kaç tane maç yapılır?

2. “ öğretmeni olmak”
“ anne olmak”
“ Kardeş olmak” bağıntılarını yansıma, simetri ve geçişme özelliklerini sağlar mı? Nedenleriyle açıklayınız.

3: β = { (x,y); x,y € IR, x-y= 2k, k bir tam sayıdır } bağıntısı verilsin.
Bu bağıntı Z de bir denklik bağıntısı mıdır?

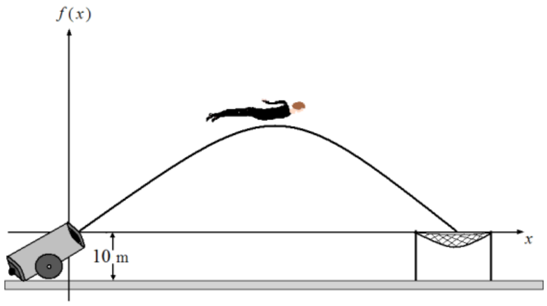
4: Üçgenlerde benzerlik bağıntısı bir denklik bağıntısı mıdır? Açıklayınız

5. Aşağıdaki paragrafta tarif edilen cisim nedir?

“Aklımdan tuttuğum obje 23 cm yüksekliğinde silindirik şekildedir. Tabanından 16 cm ye kadar düzgün yüzeyli ve çapı 4 cm dir. 16 cm den 18 cm ye kadar olan yüksekliğinde yarıçapı 7 cm olmaktadır. 18 cm ile en yüksek noktaya arasındaki yarıçap, 7 cm den 4 cm ye azalmaktadır. Bu objenin gövdesi silindiriktir. Metaliktir ve cisme dokunduğunuzda bazen sıcaklık, bazen soğukluk hissedersiniz.” Bu cisim nedir?

6. Bir top tarafından fırlatılan sirk cambazının yörüngesi $f(x) = x - \frac{1}{100}x^2$ fonksiyonunun grafiği ile veriliyor. Top ve gerilmiş ağın her ikisi de yerden 10 metre yüksekliktedir.

- Cambazın ağın ortasına düşmesi için topun ağzı ile ağın orta noktası arasındaki uzaklığı bulunuz.
- Cambazın yerden en fazla kaç metre yükselebilir?



7. Mete Bey, bir yunus balığı ile gösteri yaptı. Yunus Eğitmeni Mete Beyin verdi balığı almak için havuz yüzeyinden kendi boyunun 2 katının 1 metre fazlası kadar sıçradı. Mete bey ikinci balığı aynı şekilde tuttuğunda yunus, havuz yüzeyinden kendi boyu kadar daldı, ardından 10 m yükselip balığı aldı. Mete Bey in bulunduğu tramplenin yüksekliği değişmediğine göre yunusun balığı havuz yüzeyinden kaç metre yukarıda tuttuğunu bulunuz.

8. Aşağıda, bir yayın ucuna bağlı kütleler ile yayın uzunluğunda meydan gelen değişimler gösterilmiştir. Yay ile yayın uzunluğunun arasındaki ilişkiyi bulunuz.

Yayın ucuna bağlanan kütle (kğ)	0	1	2	3	4	5	6
Yay uzunluğu (cm)	5	9	13	17	21	25	

9. Bir spor kulübü yıllık üyelik için 200 YTL almaktadır. Üye olduktan sonra ilk ay ücretsiz sonraki aylarda 55 YTL istemektedir. Eğer C(x) x ay için ödenen ücreti gösteriyorsa, x ile C(x) arasındaki ilişkiyi gösteriniz. Bu ilişki bir fonksiyon belirtir mi? 12 ay için C(x) in grafiğini çiziniz.

10. A şehrinde 2005 yılında aylara göre yağış miktarının x ay , y ise metrekareye düşen yağış miktarı olmak üzere, y= x -12x+ 36 bağıntısına uygun olduğu görülmüştür. Buna göre, 4., 9. ,11., 12. aylarda metrekareye düşen yağış miktarı nedir?

11. Asma köprünün kuleleri 800 metre arayla ve yoldan 160 metre yükselti ile yapılmıştır. Kuleleri bağlayan tel, parabol biçimindedir. Kuleden 100 metre uzaklıkta telin yerden yüksekliği kaç metre olur?

12. Bir fabrikada iki ve dörder kişilik şişme bot üretilmektedir. İki kişilik bir botun kesimi 0,9 saatte, satışa hazır hâle getirilmesi ise 0,8 saat almaktadır. Dört kişilik bir botun kesimi 1,8 saat ve satışa hazır hâle getirilmesi 1,2 saat sürmektedir. Bu fabrikada 1 ayda bot kesim bölümünde maksimum 864 saat

ve satışa hazır hâle getirilme bölümünde 672 saat çalışılmaktadır.

Yukarıdaki koşulları yansıtan bir doğrusal eşitsizlik sistemini yazarak, çözüm kümesini bulunuz.

13. 4 tane ardışık tek sayıdan büyük olan iki tanesinin kareleri toplamı, küçük olan sayıların kareleri toplamından 34 fazla ise, bu sayılar ne dir?

14. Ali, Arda ve İdil bir oyun oynamaktadırlar. Oyunun kuralı şöyledir:
" Her bir turda kaybeden kişi diğerlerine kendi kasasından, onların kasalarındaki para miktarı kadar ödeme yapacaktır."
1. turda kaybeden Ali diğerlerine ödeme yapmıştır. 2. turda Arda kaybetmiştir ve yine diğerlerine aynı şekilde ödeme yapmıştır. 3. turda İdil kaybetmiştir ve diğerlerine yine şekilde ödeme yapmıştır. Oyunun sonunda herkes kasasındaki paralarını saymış ve her biri 24 YTL ye sahip olduklarını görmüştür. Buna göre her biri kaçar YTL ile oyuna başlamıştır.

15. x sınıftaki her bir öğrenciyi, y ise bu öğrencinin T.C. kimlik numarasını göstermek üzere, x, y sıralı ikililerinden oluşan fonksiyonun bire bir ve örten olup olmadığını araştırınız.

16. Sınıftaki öğrencilerin kümesi *A* ile kan grupları kümesi de *B* ile gösterilsin. *A* dan *B* ye tanımlanan f fonksiyonu, *A* daki her öğrenciyi *B* de kendi kan grubuna eşlesin. Bu fonksiyonun bire bir, örten ve içine olma özellikleri araştırınız.

17. Amerikalı Ekonomistler yabancı sermayeyi yatırımının, paranın sabit değeri değiştiğinde yapılması gerektiğinde gerektiğini savunurlar.
1 Ağustos, 2007 de 1 Amerikan doları 1,136235 Euro, 1 Euro ise 109,846 Japon Yenidir. F(x) , Euro alınabilecek x doların fonksiyonunu, g(x) de Japon Yeninin alınabilecek x Euro'yu temsil etsin. Buna göre,

a) Dolarla Euro arasındaki ilişkiyi kuran fonksiyonu bulunuz.
b) Japon yeni ile Euro arasındaki ilişkiyi kuran fonksiyonu bulunuz.
c) a ve b şıklarında bulduğunuz fonksiyonlardan yararlanarak, dolar ile yen arasındaki ilişkiyi bulunuz. (bu ilişki g (f(x)) dır.)
d) g(f(1000)) = ?

VITA

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EDUCATION

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WORK EXPERIENCE

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2001- Present	Hacettepe University, Elementary Mathematics Education Department	Research Assistant

PUBLICATIONS

1. Polat Z. S., Umay A. (2002). The relationship between self- monitoring and the profession of teaching. Hacettepe University Journal of Education, 23,198-204 (2002).

2. Polat Z. S., Şahiner Y.(2007). A study about the elimination of pre-service primary education teachers’s misconceptions about relations and functions Concept. Education and Science 32, 89-95.