THE EFFECTS OF PROBLEM-BASED LEARNING METHOD ON 9th GRADE STUDENTS' ACHIEVEMENT IN GEOMETRY

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ABSTRACT

THE EFFECTS OF PROBLEM-BASED LEARNING METHOD ON 9th GRADE STUDENTS' ACHIEVEMENT IN GEOMETRY

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The purpose of the study was to determine the effects of problem-based learning (PBL) on 9th grade students' geometry achievement. The study was conducted in a rural town of Ankara with 44 ninth-grade high school students. The randomized pretest-posttest control group design was used. The experimental group was instructed with hybrid PBL and the control group was instructed with traditional teaching methods. The treatment was given for 4 hours every week for a total of six weeks.

Geometry Achievement Test (GAT) was administrated as pre-test, post test and retention test to both groups to measure students' academic achievement in geometry, was developed by the researcher. This test included 18 items which were related to polygons and circular region.

In order to analyze the obtained data, Mann-Witney U, Independent T-test and one-way repeated measures Analysis of Variance were used. Analysis of post test results indicated that there was no statistically significant mean rank difference between students who were instructed by traditional teaching method and those who were instructed by PBL. There was also no significant mean difference between retention of GAT scores of the two groups. In addition, a statistically significant change in GAT scores of students who were instructed by PBL across three time periods (pre-treatment, post treatment and retention) was found. There were statistically significant mean differences between their prior and post GAT scores;

and between their prior and retention GAT scores of the PBL method group. On the other hand, there was no statistically significant mean difference between post and retention GAT scores.

The present study suggests that PBL can contribute to students' retention of geometry achievement.

Keywords: Mathematics education, Problem-based learning, traditional teaching methods, secondary school students

ÖZ

PROBLEME DAYALI ÖGRENME YÖNTEMİNİN 9. SINIF ÖĞRENCİLERİNİN GEOMETRİ BAŞARISINA ETKİSİ

Apaçık, Mükerrem
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Bu çalışmanın temel amacı problem tabanlı öğrenim yönteminin (PBL), 9. sınıf öğrencilerinin geometri başarısına etkisini incelemektir. Bu çalışma Ankara'nın kırsal bir ilçesinde, 44 dokuzuncu sınıf öğrencisi ile yapılmıştır. Rasgele seçilmiş öntest-sontest kontrol grubu çalışma deseni kullanılmıştır. Deney grubu melez PBL ile yönlendirilirken, kontrol grubunda geleneksel matematik öğretimi kullanılmıştır. Uygulama altı hafta boyunca, haftada dört saat sürmüştür.

Öğrencilerin geometrideki başarılarını ölçmek için araştırmacı tarafından geliştirilen Geometri Başarı Testi (GAT) deney ve kontrol gruplarına ön test, son test ve uygulamadan 6 hafta sonra kalıcılık testi olarak uygulanmıştır. Bu teste çokgenler ve çembersel bölgelerle ilgili 18 soru vardır.

Elde edilen sonuçların analiz edilmesi için Mann-Witney U testi, ilişkisiz örneklemler T-Testi ve tekrarlı ölçümler için tek yönlü varyans analizi yöntemi kullanılmıştır. Analiz sonuçlarına göre PBL ve geleneksel öğretim metodu ile eğitim yapılan grupların test başarıları arasında anlamlı bir fark bulunamamıştır. Ayrıca iki grubun kalıcılık testi ortalamaları arasında da anlamlı bir fark yoktur. Diğer taraftan, PBL ile öğrenim görülen deney grubunun üç test periyodunda öğrenci başarıları arasında anlamlı fark bulunmuştur (ön, son, kalıcılık testleri). Test sonuçlarına göre, ön test ve son test sonuçları ile ön test ve kalıcılık testleri arasında anlamlı bir fark vardır. Diğer yandan son test ve kalıcılık testleri ortalama skorları arasında istatistiksel olarak anlamlı bir fark yoktur.

Bu çalışma, PBL’nin öğrencilerin geometrideki başarısının kalıcı olmasına yardımcı olabileceğini iddia eder.

Anahtar Kelimeler: Matematik eğitimi, Problem tabanlı öğrenim yöntemi, geleneksel öğretim metotları, Ortaöğretim okulları öğrencileri.

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LIST OF ABBREVATIONS

ABBREVATIONS

α	: Level of Significance
λ	: Lambda
η2	: Eta Squared
ANOVA	: Analysis of Variance
CG	: Control Group
Df	: Degrees of Freedom
EG	: Experimental Group
F	: F distribution
GAT	: Geometry Achievement Test
LSD	: Least significant difference
M	: Mean
n	: Number
p	: Probability
PBL	: Problem-based Learning
Std. Error	: Standard Error
SD	: Standard Deviation
TDGI	: Traditionally Designed Geometry Instruction

CHAPTER 1

INTRODUCTION

‘Why do we have to learn such unnecessary subjects and operations?’ is a typical question to be heard in high schools. Or we may meet a parent anytime complaining ‘my son/daughter is very talented in maths/science but s/he is doing nothing to improve him/herself, s/he isn’t curious about anything’. Such comments serve as meaningful feedback to educators on the effectiveness of teaching methods and curriculum on learning motivations of learners. Unfortunately, this feedback indicates that traditional curriculum does not encourage curiosity, critical thinking and ownership of task. Indeed traditional education, instead of presenting students with problems, seems to be more preoccupied with transferring content, especially content which teachers themselves are most knowledgeable or comfortable with, or content they think will be useful for solving some problems (Tan, 2003). Learners, on the other hand, are thought to be responsible for acquiring every piece of knowledge offered by teachers.

Recently, it has been observed that students, whether consciously or unconsciously, want to be in control of their learning process, and learners are more motivated to learn a particular discipline when they believe that the learning process is under their own control (Bandura, 1997). Actually learners are more motivated when the subject, they are learning, is carrying carries profound significance and value for them (Zimmerman, 2000; Ferrari & Mahalingham, 1998). Hence, educators, by evaluating new approaches developed new curricula to shift the centre of teaching and learning activity from content and the teacher, to focus on content coverage and they argued that better models engaged students in problem scenarios that are similar to real life situations (Glasgow, 1997).

The search to create a learning environment in which the learner is the owner/a part of the learning activity in which real life situations are focused resulted in the construction of problem-based learning (PBL); one of the most popular curricular innovations in education (Savin-Baden, 2000; Tan, 2000).

PBL gained admiration following the research of Barrows and Tamblyn (1980) on the reasoning abilities of medical students at McMaster Medical School in Canada. Following PBL's success of in medical schools, Walton and Matthews (1989) extended the limits of PBL to a general educational strategy and a philosophy in preference to its former teaching approach status.

PBL is defined as a strategy facilitating the development of self-regulated learning skills which make students metacognitively, motivationally, and behaviourally active participants in their self learning (Galand, Bentein, Bourgeois, & Frenay, 2003). In PBL, students learn by solving problems and reflecting on their own experiences (Barrows & Tamblyn, 1980). PBL is developed to support students in becoming active learners because it situates learning in real life problems and makes students responsible for their own learning. It has a dual benefit on helping learners develop strategies and construct knowledge (Hmelo & Ferrari, 1997). Roh (2003) defined PBL as a learning environment where problems drive the learning. Learning is initiated with a problem and the problem is posed such a way that students need to gain new knowledge before they can solve the problem. Rather than looking for a single correct answer, students understand the problem, collect required new information, identify solutions, evaluate options, and organize conclusions.

Despite common attributes of PBL, its models and implementations vary considerably. These models can be determined depending on factors such as unit area, grade level, characteristics of problem and tutor's philosophy of education. One of these models is hybrid PBL. Hybrid PBL is often used as an entry point into PBL in the course transformation process and problem-driven learning is used non-exclusively in a class and this hybrid model may include separate lecture segments or other active-learning components. For instance different hybrid models may include mini-lectures if needed, whole class discussions, preparation of group product, group discussions, research, exams and other formal assessment (Smith, Sheppard, Johnson, & Johnson, 2005).

As hybrid model has been defined as an entry point into PBL, in this thesis hybrid PBL was conducted in order to examine the effects of PBL in a high school mathematics class.

1.1. Significance of the Study

The purpose of this study is to find a significant effect of two teaching methods PBL and traditional teaching method on students' academic achievement. The study concentrated on how PBL can be conducted at high school level and how traditional teaching methods can serve as an attractive learning atmosphere by including different communication models.

As a teacher, the researcher frequently hears students' complaints about mathematics. They tend to think that mathematics have many abstract units and do not have much usage in real world. As Tan (2004) stated, there is the increasing demand for bridging the gap between theory and real-world. The gap between the theory of mathematics and the real world is considerably high compared to most other disciplines as mathematics is thought to be abstract. Hence, this study aims to build a bridge between real world and mathematics knowledge by means of PBL. In addition to this, PBL being comprised of real-world competencies such as independent learning, collaborative learning, problem solving and decision-making skills provided a strong rationale for adopting PBL (Tan, 2004).

In the literature there are many studies of PBL in different disciplines such as medicine, science, educational administration, business, educational psychology, engineering, chemistry, various undergraduate disciplines, and K–12 education (Boud & Felletti, 1991). The disciplines that especially purported to have benefited from the effectiveness of PBL are medicine science and gifted education. Nevertheless, this evidence has been derived from studies which were mostly conducted at university level. Indeed, the extent to which this evidence generalizes disciplines and population has been questioned by Hmelo-Silver (2004), who also state that there are less empirical studies as to what students are learning and how they are learning. There are also few implementations in mathematics comparing traditional teaching methods and PBL in mathematics. In Turkey, on the other hand, there are few implementations of PBL in mathematics in primary school and university level but the researcher could not reach a study, in mathematics, comparing student's achievement between PBL and traditional teaching method at high school level. What is more, in most studies only the lectures were observed within the traditional teaching method. In this study, however, traditional teaching was enhanced by different communication models such as discussion. Although PBL was conducted mainly in higher education, in medical schools for example, this thesis claims that PBL can be conducted in mathematics at high school level. Moreover this study claims that PBL may have a positive effect on students' achievement in mathematics at high school level. Thus, this study aims to present valid data and results about PBL to educators in order to enlighten the issue and promote further studies on mathematics.

Lastly, the mathematics teaching in Turkey is mainly exam-driven. There are too many exams in students' school life not only in-class exams but also selection exams such as secondary education entrance examination (SBS) at grades 6, 7 and 8 and university entrance examination (ÖSS), which are all multiple choice question type tests. Multiple choice-driven styles unfortunately promote rote learning and memorisation. As a result, traditional teaching, mainly lecturing is seen as the sole means to prepare students for success in for those exams in both schools and exam preparation centers (Dersane). On the contrary, it is possible to make students wonder why things in mathematics are valuable to search for solutions while teaching the curriculum. The results in this study may support this claim and the mathematics education community in Turkey can argue on the findings.

1.2. Main and Sub-problems of the Study and Associated Hypotheses

In this section the main and sub-problems and hypotheses are stated.

The main problem of the study is "What is the effect of problem-based learning on 9^{th} grade students' geometry achievement?" Its sub-problems are:

1. Is there a statistically significant mean difference between students instructed with the traditional teaching method and those instructed with problem-based learning with respect to geometry achievement?

2. Is there a statistically significant change in the Geometry Achievement Test scores of the students instructed with problem-based learning across three time periods (pre-treatment, post treatment and retention)?

In order to examine the sub problems, null hypotheses were stated and tested at a significance level of 0.05. The hypotheses regarding the sub-problems are stated below:

$H_0$1.1: There is no statistically mean difference between students instructed with traditional teaching methods and those instructed with problem-based learning with respect to post geometry achievement.

$H_0$1.2: There is no statistically mean difference between students instructed with traditional teaching methods and those instructed with problem-based learning with respect to retention in geometry.

The hypothesis of the second sub problem can be stated as:

$H_0$2: There is no statistically significant change in the Geometry Achievement Test scores of students instructed with problem-based learning across three time periods (pre-treatment, post treatment and retention).

1.3. Definition of Terms

The definitions of PBL, traditional teaching method, academic achievement and problem which this study examined are stated below.

Problem Based Learning (PBL): Problem-based learning (PBL), teaching/learning method examines problems as a base to encourage student learning of knowledge and skills. In PBL, students focus on a problem or specifically ill structured problems in an organized, logical method. This method of teaching is inquiry-based and student centered. According to Barrows (1996) students will study in small groups, and the teacher serves as a guide for students through the problem solving period rather than merely being a source of knowledge.

Hybrid Problem Based Learning: Camp (1996) defines the true PBL model to possess the following characteristics; active, adult oriented, problem-centered, student-centered, collaborative, integrated, and interdisciplinary and deviation of one of these characteristics results in a method which is not pure PBL. This model is so strict that if the whole environment of learner is not PBL then it is not pure PBL again. According to Camp (1996) high school implementations of PBL cannot be pure PBL because of the curriculum. In high schools, teachers have to cover some curriculum and this prevents pure PBL. In addition to this, pure PBL is achieved when all environments are PBL and this not possible in high schools.

Hybrid PBL is often used as entry point into PBL in course transformation process. Problem-driven learning is used non-exclusively in a class and a hybrid model may include separate lecture segments or other active-learning components. There are many types of hybrid models including mini-lecture if needed, whole class discussion, preparation of group product, group discussion, research, exams and other formal assessment, and writing (Smith, Sheppard, Johnson, & Johnson, 2005).

Traditional Teaching Methods: according to Morgan, Whorton and Gunsalus (2000), traditional teaching methods may include many different teaching methods as listed below: (a) teacher lecturing and student note-taking, (b) individual student pen-and-paper practice problems, (c) pen-and-paper assessment, (d) laboratory activities with predetermined outcomes in science classes, and (e) discussions.

Academic Achievement: The students' scores obtained from the Geometry Achievement Test developed by the researcher.

Problem: Hmelo-Silver (2004) states that problems need to be complex, ill-structured and open-ended. These characteristics foster flexible thinking. A good problem should be realistic and resonate with the learners' experiences and it helps the learner to evaluate the effectiveness of their knowledge and learning strategies. A good problem should require multidisciplinary solutions so that it motivates students to know and to learn different disciplines. Lastly a good problem should encourage students to study in groups and it should help students to improve their communication skills.

CHAPTER 2

LITERATURE REVIEW

The related literature is reviewed in this chapter. The literature is examined in three sections; theoretical background, traditional teaching methods and review of empirical studies.

2.1. Theoretical Background

Within today's rapid changing technology, public changes. Thus, individuals are expected to gain knowledge and skills which could be used in original situations. Hence, workplace realities force education to contain some features such as; familiarizing students to the necessary principals related to the problems, available to face in the future, providing students with the knowledge that is relevant to these high-impact problems and improving skills in implementing this knowledge. In addition to these, education should develop problem-solving skills, skills in implementing solutions, leadership skills that facilitate collaboration, and an array of affective capacities and self-directed learning skills of learners. Nevertheless program designers for traditional programs make some critical assumptions while designing educational program. First, educational program contains the knowledge which students need order to build their future academic role. Second, students will be able to remember the achieved knowledge when it is essential or appropriate. Thirdly, implementing this knowledge is not a critical concern. Indeed it is trivial. Forth, the context in which the knowledge is learned has little impact on subsequent recall or use. Moreover, program designers imagine that knowledge is achieved most effectively when it is organised around the disciplines and taught through lecture and discussion. Finally, they assume that the aim of student evaluation is to establish whether students recall the knowledge to which students have been exposed (Bridges & Hallinger, 1995).

Contrary to the traditional programs expressed above, constructivists believe that knowledge is not absolute, but rather is constructed (Savin-Baden & Major, 2004). Piaget (1970) states that learning takes place when a student creates a significant product or interpretation of acquired knowledge. This study has been basis of constructivism and constructivist theory. That is, the study claims that learners gain knowledge by interacting with the environment. Vygotsky (1978), on the other hand, focuses on the cultural and social aspect of learning and the whole activity which promotes problem-solving and scientific inquiries. He defines a learning community where novices learn with the help of learned adults.

Wood (1995) states his ideal constructivist learning environment as:

> "Instead, teaching becomes a matter of creating situations in which children actively participate in scientific, mathematical, or literacy activities that enable them to make their own individual constructions. To teach well from this perspective, teachers will need opportunities in which they can learn about their students' construction. This can be accomplished by creating settings that encourage children's sensor motor and mental activity and providing social situations in which communication can take place. Some examples of such social arrangements are whole-class discussions of scientific experiments, small-group cooperative problem solving in mathematics, and written drafts shared with others in the course of composition writing"

which is parallel to PBL in all principals. Both PBL and constructivism have common principals such as; open ended, real life design/problem, learner is the owner of the task and process, encourage learners' thinking and opportunity of learner to reflect his or her ideas (Savery & Duffy, 1995).

As Barrows (1996) defined, there are some fundamental characteristics of PBL. First of all, learning needs to be student-centered. In the light of this principal, learning has to occur in small student groups under the guidance of a tutor. The roles of these tutors are perceived as being facilitator or guide. In PBL, authentic problems are primarily introduced to students in the learning sequence, before any preparation or study has occurred and these problems dealt with are used as an instrument to achieve the required knowledge and the problem solving skills necessary to eventually solve the problem. That is, finally, new information needs to be acquired through self-directed learning.

Boud (1985), one of the strong supporters of the approach, though broader, has also outlined characteristics of PBL. He noted that the most important characteristics of PBL is its problem centeredness and student centeredness. In addition, Boud (1985) outlined eight characteristics of many PBL courses; perception of the base of experience of learners, emphasis on students taking responsibility for their own learning, crossing boundaries between disciplines, link of theory and practice, centre on the process rather than the outcomes of learning of knowledge acquisition, alter in instructor's role from that of instructor to that of facilitator, change in focus from instructor's assessment of outcomes of learning to student self assessment and peer assessment, and focus on communication and interpersonal skills. Another fundamental characteristics of PBL is that students learn by analyzing representative problems/cases which are constructed to be a part of daily life (Dochy , Segers , Bossche, & Gijbels, 2003).

According to Hmelo-Silver (2004) main goals of PBL are to assist learners in gaining extensive, flexible knowledge, constructing effective problem-solving skills, having self-directed, lifelong learning skills, and becoming effective cooperative learners and intrinsically motivated to learn. As a result, if it was possible to demonstrate such a system in which student's achievement on conventional mathematical task were powered by PBL, the basic value of teaching would be affected by student's choice on whether to continue to study mathematics, generate a belief system empowering and supporting further learning Clarke, Breed and Fraser (2004).

PBL environment is usually constructed mainly by cooperative learning. Indeed, cooperative problem-solving groups are a key feature of PBL (Hmelo-Silver, 2004). PBL can be implemented for many reasons and invariably chances for team building to be done at first (Savin–Baden, 2000). Brown (1995) suggests that the small group discussions and debate in PBL sessions enhances problem solving and higher order thinking and promotes shared knowledge environment. In the studies concerning mathematics PBL environment is described as learning/ teaching environment that organizes mathematics education around ill structured problems and problem solving activities in small groups. In this strategy, students are believed to have more opportunities to think critically, present their own creative ideas, and communicate with peers mathematically (Erickson, 1999; Carpenter, Ansell, Franke, Fennema, & Weisbeck, 1993; Hiebert et al., 1996).

A very important part of PBL is the problem itself. Hmelo-Silver (2004), a proponent of PBL, states that problems need to be complex, ill-structured and open-ended. These characteristics foster flexible thinking. A good problem should be realistic and resonate with the learners' experiences and it helps learners to evaluate the effectiveness of their knowledge and learning strategies. A good problem should encourage students to study in groups and it should help them to improve their communication skills. Lastly, a good problem should require multidisciplinary solutions so that it motivates students to know and to learn different disciplines. As Boud (1985) mentioned, PBL is a beneficial learning environment for multidisciplinary approaches. In a nutshell, a problem should consist of many interrelated pieces and as a result the problem should direct learner to collect data pieces in many data sources.

Stepien, Gallagher and Workman (1993) state a brief description of problem. A good problem should encourage students to know more information than is initially presented to them. Each problem should be unique and open ended. It should be a real world problem and it should foster flexible thinking

In the above paragraphs, the researcher has reported the general characteristics of PBL from the available literature. As can be seen, proponents of PBL seem to agree on the characteristics of PBL but models and implementations of PBL vary considerably. It is worth elaborating on these different models and implementations of PBL. According to Barrows' (1986) taxonomy, PBL has six models. First, lecture-based models: in this method students are lectured and then case materials are presented for them to create a connection with the lectured information. In case-based lectures, students are lectured after a case. In another method, case method, students are given a case and study on it. In modified case-based model students are provided with a case and are responsible for reaching some conclusions so that they can be given some more knowledge. In the problem-based model, learners are given a problem and they independently study on the problem. The last one is the closed-loop problem based. This model is an extension of the problem-based model. In this model students are not as free as the problem-based model. They are questioned about their decisions and resources during the activity.

Another modeling decreases the number models but extends their limits. Ellis, Carswell and Bernet (1998) states three categories of PBL methods. The first category is the problem-based approach, in which the material is presented in normal lectures, but problems are used to motivate students and demonstrate the theory. The second category is a hybrid model, guided PBL. In this category, problems are solved in groups, but also lectures may be used to present the fundamental concepts and some of the more difficult topics. The third one is a full PBL, where the problems drive the entire learning experience; in this form there are no lectures from the expert and groups or individuals work independently of one another.

Hybrid model of PBL is very flexible compared with pure PBL. In countries where teacher centered instruction is valued, the hybrid PBL is preferred to the pure PBL. For instance, hybrid model of PBL has become very popular in most Asian medical schools. In their PBL in hybrid model, PBL tutorials are run together with other modes of learning such as lectures, small group tutorials, special study modules and research attachments (Khoo, 2003).

Smith, Sheppard, Johnson and Johnson (2005) state that hybrid PBL is often used as entry point into PBL in course transformation process. Problem-driven learning is used non-exclusively in a class and hybrid model may include separate lecture segments or other active-learning components. There are many types of hybrid models including mini-lecture if needed, whole class discussion, preparation of group product, group discussion, research, exams and other formal assessment.

O’Kelly (2005) applied a hybrid PBL model in computer sciences with first year university students. In this model, some techniques such as student driven tutorial, PBL style lectures, student induction, lectures, and laboratory activities were used. The problems implemented in the study were in a range from open ended to classical exercises. In the study there are three major differences between his hybrid models used in this case study and the pure PBL model: the duration of the problems, the continued inclusion of at least one lecture every week (PBL style lectures) and the methods of assessment (which include traditional exams). As a result the hybrid PBL model implemented provided a good transition for students to a university environment and the model provided a framework to assist the students in problem abstraction, problem definition and problem refinement.

Similar to the previous study, Wu (2006) applied a hybrid PBL model in computer sciences offered to first year university students. In his study he gave examples first to construct the reality on the unit and then an open ended problem for students to work in groups. His hybrid PBL model differs from the pure PBL from three points, duration/role of examples and problems, lecturing part and the method of assessment which still includes traditional examinations. As a result of this study, the hybrid PBL model proved to be a good transition for students to a university environment and framework to assist the students in problem abstraction, problem analysis, and problem solving.

Among many models, Camp (1996) states a very specific and valuable model for high school PBL model. First of all Camp (1996) defines a true PBL model as being; active, adult oriented, problem-centered, student-centered, collaborative, integrated, and interdisciplinary and deviation of one of these characteristics results in a method which is not pure PBL. Similarly, this model is so strict that if the whole environment of learner is not PBL then it is not pure PBL. According to Camp (1996), high school implementations of PBL can not be pure PBL. He identifies the curriculum as the culprit that ‘corrupts’ the PBL. In high schools teachers have to cover some curriculum and this prevents pure PBL. In addition to this, pure PBL is achieved when all environments are PBL and this not possible in high schools. Another reason is the number of students in classes. It is difficult to apply PBL in a class with 30 students.

To sum up models and implementations of PBL vary considerably. The researchers may choose one of the models depending on reasons such as purpose, discipline, grade level, characteristics of problem/case and education philosophy.

In this study, PBL implementation was hybrid. That is, learning activity was student-centered and it occurred in small student groups under the guidance of a tutor. The tutor acted as a facilitator. Authentic problems were primarily encountered in the learning sequence and new information needed to be acquired through self-directed learning. In addition the hybrid model in this study included whole class and group discussions, preparation of group product, and authentic problems was used to not only involve students in learning environment, but also to teach some part of theory. Students also studied some traditional problems in some parts of the treatment. Lastly, traditional assessment was used in order to assess students' achievement.

2.2. Traditional Teaching Methods

Although there are many studies not in favour of traditional teaching methods and most disciplines are moving to more cooperative learning teaching methods, as Borich (2004) stressed, traditional teaching methods are the most appropriate method to teach knowledge not easily accessible to students. Additionally, he stated that a traditional teaching methods lesson consists of three parts: introduction, body, and conclusion. During the first few introductory minutes the teacher summaries past knowledge In other words, the teacher aims to build a connection between past learning and new. Reviewing is an opportunity for students that do not have the needed prior knowledge to construct information appropriately. Following to the introductory review, the body of the lesson contains the information, facts, and concepts which will be presented to the students. This information is presented at a suitable pace that is not too fast. Furthermore, the teacher needs to ensure that the content is organized so that the student can observe the framework. Finally, the teacher should encourage note taking, use different styles of presentation, start some discussions and ask open ended questions and problems to students. In summary the instructor should use many techniques in order to activate students.

Brookfield (2006) indicates three important characteristics of traditional teaching methods as follows; using variety of teaching and communication models, and a clearly organized lecture so as students can follow the lecturer's thought and modelling expected learning behaviours and outcome.

For many schools and instructors traditional teaching methods are most appropriate because it is the most economical method of teaching. For the large part, teachers can handle teaching with easy-to-find materials such as chalkboards, boards, and worksheets. (Herreid, 2003)

Another important advantage of traditional teaching methods is its flexibility. The flexibility of traditional teaching methods allows the teacher to change the tempo of the class in respect to the students and unit being taught. In addition, the flexibility allows the teacher to introduce new information and activities into traditional teaching methods with ease. Through observation and questioning, the teacher rearranges the lesson to help students better realize the material and reduce misconceptions (Dobbs, 2008).

Despite the various benefits of traditional teaching methods, not all of these methods are the best practice for all students because different students may have varying dispositions such as different learning styles, intelligence levels, and attitudes towards subject. Actually, traditional teaching methods are usually not appropriate teaching method for students with a more holistic learning style; indeed some instructors may not enrich their discourse in which traditional teaching method can provide the best learning opportunity for students with holistic perception abilities (Borich, 2004).

In studies comparing gained achievement between PBL and traditional teaching method PBL usually had a negative tendency (Dochy, Segers , Bossche, & Gijbels, 2003).

In summary, despite its disadvantages, traditional teaching methods are still one of the most appropriate teaching methods for many schools as it is flexible and economical. Additionally, traditional teaching method seemed to be slightly more effective in achievement tests when compared with PBL.

The traditional teaching methods implemented in the study contained teacher lecturing, student note taking, individual student pen and paper practice problems and pen and paper assessment. In addition to these, discussions comprised important sections of the instruction

2.3. Review of Empirical Studies

Donald Woods planned PBL in 1966 first while he was teaching in Mc Master University medical school and hospital. Studying on the new instruction in 1969, PBL was first conducted in a classroom with 19 students. In the early implementations of PBL, Donald Woods focused on stimulating patient problems in consistence with a practising physician. Students studied in small groups and they did not attend conventional lectures. Instead they were given a problem pack. In comparison to the control group, students who had learned by PBL, were more motivated and were reported to have gained more problem solving skills (Barrows & Tamblyn 1976; Savin-Baden & Major, 2004). PBL has been effective on medical education for last four decades. In PBL, students studied on clinical problems in small groups and the approach has been evaluated as being a reform in medical education literature.

There are few implementations of PBL in elementary and high schools. These implementations of PBL in elementary schools and high schools have resulted in students' achievement, promoted critical thinking skills as well as long lasting learning (Duch, Groh, & Allen 2001; Gordon, Rogers, Comfort, Gavula, & McGee, 2001; Norman & Schmidt, 1992). The review of Norman and Schmidt (1992) stated that, compared to traditional lecture forms, PBL may direct to better retention of knowledge after some weeks up to years. This result is also true when the post test of PBL group is weaker than that of group instructed with traditional lecturing method

Before introducing relevant empirical studies on PBL, a meta analysis will summarize the results of empirical studies. Dochy, Segers , Bossche and Gijbels (2003) examined the 43 empirical studies. All these studies presented the effects of PBL on knowledge and 25 of them indicated the effects on application of data. These 25 studies concerning skills of students due to application of knowledge suggested a strong positive effect, with a combined effect size (ES= 0,46), of PBL. None of these 25 studies indicated a negative effect. The result examined in the meta analysis presented an effect size for skills which was moderate and had a practical significance. On the other hand, among the 43 empirical studies examined in meta analysis, effects of PBL on knowledge achievement of learners suggested a negative tendency, with a significantly negative effect size (ES= -0,23). Another result of the meta analysis has to be indicated. Students gained knowledge levels had a tendency to negative results however the retention period of knowledge was longer in comparison to that of knowledge gained in conventional classrooms.

It is worth focussing on empirical studies one by one. First of all, the dissertation of Griffith (2005) examines the effects of PBL on 727 volunteer participants in South California Public High School. In the study the grade level is not indicated. The empirical study took six weeks with the following results. The six weeks challenge has a positive effect on learner's attitudes and interest in science, mathematics, engineering and technology. On the other hand there is an important limitation of the study. As the sample of the study was selected from volunteer students, characteristics of the students may not be the same as the whole group in the school where the study took place.

In another study an oriented PBL instruction program on algebra I, algebra II and geometry classes, namely Interactive Mathematics Program (IMP), aiming at problem-solving, reasoning and communication, produced significant results. First of all, IMP students rated themselves as significantly more mathematically able as did the algebra students. In addition to this, IMP students held a significantly more positive attitude towards their mathematics classes than did the algebra students. There were also differences on students perception of mathematics; IMP students were significantly more likely to perceive mathematics as a mental activity and IMP students held beliefs consistent with a view of mathematics as arising from individual and societal need; while algebra students were more likely to view mathematical ideas as having an independent, absolute and unvarying existence. Moreover, the IMP students were significantly more likely to perceive mathematics as having applications in daily use. Lastly, IMP students were significantly more likely than algebra students to believe that mathematical ideas can be expressed in everyday words that anyone can understand (Clarke, Breed, & Fraser, 2004).

In the dissertation of McCarthy (2001), a qualitative study, second grade elementary school students were instructed in light of PBL for eight 45 minutes sessions. The outcomes of the study indicated that students improved their mathematical understanding. However, the researcher does not state a clear definition of PBL and does not mention about cooperative design, one of the main characteristics of PBL.

In Christensen's (2008) qualitative study various effects of PBL on the mathematics classroom were stated. It was concluded that mathematical content with which students become familiarized is the mathematics that actually has a specific direct application value for a certain educational programme and different groups of students may eventually learn different parts of mathematics depending upon the project they write, but in return, they are trained directly in closing the gap between formalism and application. In addition to these results, students are given the opportunity to learn how mathematics is applied and it may even vary which mathematical approach should be used, depending upon the specific application scenario. His last conclusion is that the PBL model can integrate mathematics in an inter-disciplinary study of a real life problem.

In the experimental study of De Corte et al. (1998), PBL and traditional lecture based teaching model in fifth graders were compared in mathematics. As a result of the study peers instructed with PBL performed better than peers instructed with a traditional lecture based teaching model. In addition to this, students exposed to PBL were better at problem solving.

Lastly some empirical studies from Turkey will be stated. Sungur (2004) studied of the effects of PBL on high school biology instruction. This empirical study was implemented with 10^{th} grade biology students. PBL was reported to have had a positive effect on learner's achievement. In addition to this, PBL improved students' perceived intrinsic goal orientation and perception of biology in terms of interest, importance, and utility (task value). Moreover PBL improved students' use of elaboration strategies, metacognitive self-regulation, critical thinking, regulation of their effort, and peer learning. On the other hand PBL was indicated to have had no effect on students' perceived extrinsic goal orientation, control of learning beliefs, self-efficacy for learning and performance, and test anxiety. In sum the study has emphasized PBL's a positive impact on achievement and motivation of students.

In another study which aims to increase students' mathematics performance in collaboration with other sciences in geophysics engineering at Dokuz Eylül University in the 2002 fall semester, the results indicated that PBL was effective in increasing students’ participation and developing learning performance (Özel, Timur, Özyalın, & Danışman, 2005).

Yaman and Yalçın (2005) studied the impacts of PBL in developing problem solving skills and self-efficacy beliefs level towards science teaching of prospective teachers. The study was conducted at Gazi Educational Faculty in 2002-2003 academic years with 215 prospective teachers in the experimental group and control group. Results demonstrated that prospective teachers' problem solving skills and self-efficacy beliefs toward science teaching developed more with the group that received PBL treatment (experimental group) than control group students. Moreover it was concluded that PBL was more effective than traditional methods in developing students' different skills.

Yurd and Olğun (2008) implemented PBL in order to eliminate the 5th grade students’ misconceptions of “Light and Sound” in the science and technology course. The study was conducted in two groups with 99 5th grade students in the 2005-2006 academic year. The findings of the study indicated that, experimental group students’ understanding of what? was better than the control group students’ and most of the misconceptions of the experimental group were nullified.

Selcen (2008) studied the effects of PBL and the traditional teaching method on 7th grade elementary school students’ environmental attitude. The sample consisted of 95 students in two PBL groups and one traditional group. The attitudes of students were determined by Environmental Attitude Questionnaire. The results of the study revealed that, one of the PBL groups had significantly more positive environmental attitudes in general environmental awareness and general attitude toward the solutions dimensions than the traditional group. On the other hand, traditional group had significantly more positive attitude than the other PBL groups in respect to students’ awareness of individual responsibility determined after the treatment.

In Turkey, there is only one study that the researcher could reach in geometry. In Günhan and Başer’s (2006) study, the effect of PBL on 7th grade students’ attitudes towards mathematics and achievement were examined. In 2005-2006 academic year, the study was conducted with two groups, a control group and an experimental group, at a private school in İzmir. The control group received instruction via traditional teaching methods and the experimental group were exposed to PBL. Geometry Achievement Test conducted in the study contained both real life problems and traditional multiple choice questions. Hence, the study is a hybrid PBL implementation in the light of literature. The results of the study indicated that PBL, compared to traditional teaching methods, had more positive effect on students' attitudes towards mathematics and achievement.

In summary, there are many studies on PBL which mainly support that PBL will increase students' motivation and improve students' abilities such as thinking critically, presenting their own ideas, solving problems, and communicating with peers mathematically. In spite the various studies already conducted, there were only a few studies comparing PBL and traditional teaching methods in achievement in mathematics that the researcher could reach.

Chapter Summary

In the light of the literature review, it seems that PBL is a developing instructional strategy with the following basic characteristics: learning needs to be student-centered and it has to occur in small groups, the tutor is a facilitator or guide, real life or/and ill structured problems are primarily encountered in the learning sequence and problems are used as an instrument to achieve the required knowledge and the problem solving skills necessary to eventually solve the problem and new information needs to be acquired through self-directed learning.

The empirical studies are mostly in medicine and science moreover effect of PBL on mathematics is questioned by some educators. There are many studies in university level but less in high school level. In Turkey there are few studies comparing PBL with traditional teaching method in high school level in different disciplines. Finally, the researcher could not reach any studies conducted in high school mathematics classes in Turkey.

In empirical studies comparing PBL with traditional teaching methods in achievement, PBL mostly has a slightly negative effect or there is no significant difference in studies. There are fewer studies which indicate a positive effect on student achievement. On the other hand, positive effect of PBL on retention is accepted by educators and researchers.

CHAPTER 3

DESIGN OF THE STUDY

This chapter describes the treatment, definition of variables, sample of the study and lists the limitations of the study.

3.1. The Experimental Design

In this study the randomized pretest-posttest control group design was used (Fraenkel & Wallen, 1996). Before 9th grade students were registered to the school in august and september, the researcher and school administration agreed on forming 9th grade classes randomly in order to satisfy randomization for this study. During registration, the students were randomly distributed to three classes by means of drawing lots. As a result three classes were formed comprised of 22, 23 and 24 students respectively. Two of these classes were randomly chosen as the control group and experimental group. Table 3.1 shows the research design of the study.

Table 3.1 Research design of the study

Groups	**Before Treatment**	**Treatment**	**After Treatment**	**Follow-up**
CG	GAT	TDGI	GAT	GAT
EG	GAT	PBL	GAT	GAT

In this table, EG represents the experimental group instructed with hybrid PBL. CG, on the other hand, represents the control group receiving traditionally designed geometry instruction. GAT is geometry achievement test. PBL represents hybrid problem-based learning while TDGI is traditionally designed geometry instruction.

As seen in Table 3.1 GAT was administered to both the experimental and control groups before and after the treatment to determine whether there was a significant mean difference between two groups with respect to previous academic achievement in geometry. Six weeks following to the treatment, a retention test was applied in order to determine whether there was a significant mean difference between the two groups with respect to previous academic achievement in geometry and whether there were statistically significant mean scores of the students instructed with problem-based learning across the three time periods (pre-treatment, post treatment and retention).

3.2. Subjects of the Study

Subjects of this study consisted of 44 ninth grade students (n=28 boys and n=16 girls) instructed with the same mathematics teacher in an Anatolian high school in a rural town of Ankara. The study was carried out in the fall semester of the 2007-2008 academic year. Students were selected by using scores obtained from Secondary Education Entrance Examination (OKS). The students' average mathematics scores were 8 out of 25. The mathematics grades of the students in the experimental and control group were 4.52 and 4.45 over 5 respectively at grade 8. The mean age of the students in the experimental group and control group was 14.6 and 14.9, respectively. Four of the students, two in experimental, two in control group, were repeating ninth grade since they had failed the previous year. Two instructional methods, hybrid PBL and traditional teaching method were randomly assigned to the experimental and the control groups. The number of students in both the experimental and control group was 22.

Table 3.2 shows demographic information regarding the education level and work status of the parents of students'.

Table 3.2 Parents' Education Level and Work Status

	Control Group (%)		**Experimental Group (%)**	
Education Level	Mother	Father	Mother	Father
Primary School	34.8	17.4	50	18.2
Junior High School	30.4	8.7	18.2	13.6
High School	21.7	39.1	13.6	36.4
University	13	30.4	13.6	22.7
Ms	0	4.3	4.5	4.5
PhD	0	0	0	4.5
Work Status	Mother	Father	Mother	Father
Employed	13.5	91	18	100
Unemployed	86.5	0	82	0
Retired	0	9	0	0

In Table 3.2, a difference between fathers' and mothers' education level could easily be observed. 27% of the fathers were university graduates. This rate is considerably high for a rural town. Some of the students were attending school from Ankara and this reason might have increased the rate of university graduated fathers. There is also a difference between fathers' and mothers' work status. Most fathers work and the rest of them are retired. On the other hand, only about 16% of mothers work.

3.3. Variables

The independent variable in this study was treatment.

The dependent variables in this study were students' academic achievements measured by GAT.

3.4. Instrument: Geometry Achievement Test (GAT)

Geometry Achievement Test was developed by the researcher (see Appendix B). It was used to determine students' achievement on course objectives (see Appendix A). The unit was formed by the researcher and it consisted of the topics in

10^{th} and 11^{th} grade geometry courses. A table of specification was prepared (See Appendix C). The questions were investigated by two high school mathematics teachers. Various questions were revised in respect to their comments. There were 18 multiple choice items with one correct answer and 4 distracters. There are 6 questions on triangles, 1 question on hexagons, 3 questions on parallelograms, 2 questions on rectangles and squares, 1 question on quadrilaterals, and 3 questions on circles and circle pieces.

The researcher has various reasons for preferring to use multiple choice. There are two types of assessments in PBL, traditional assessment and authentic assessment; in authentic assessment students are assessed by real world situations and problems (Savin-Baden & Major, 2004). In this way of assessing, the aim is not only grading students. Moreover, in traditional assessment, the basic concern is to determine students' achievement level and in traditional assessment multiple choice examinations, true or false questionnaires or fill in the blank quizzes are used (Savin-Baden & Major, 2004). As the aim of this study was to assess students' achievement, GAT contained multiple choice questions in order to determine students' level of comprehension and knowledge.

Two of the sample questions in GAT are as follows:

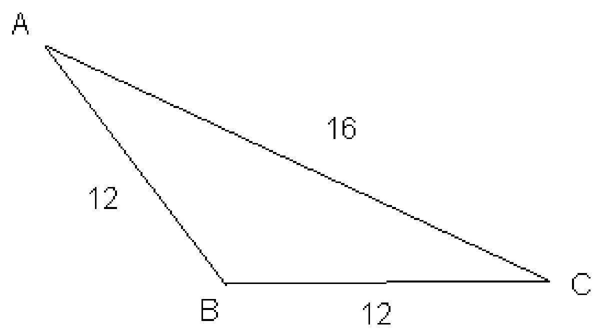

Figure 3.1 A sample question: isosceles triangle

ABC is a triangle, |AB|=|BC|= 12, |AC|=16, Area(ABC) ?

In order to solve this question, students should know the characteristics of isosceles triangle; if we draw a height from corner B to side [AC] then the height divides the base [AC] in to two equal parts as follows:

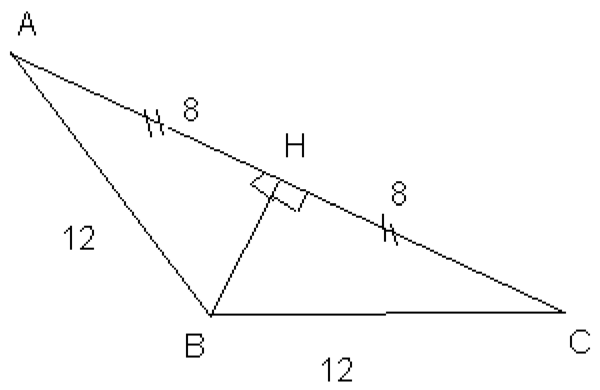

Figure 3.2 A sample question and the solution

In order to solve the question, students will have to find the measure of [BH] =height (h) by using Pythagoras Rule $12^2= h^2+8^2$. Lastly the area of triangle ABC is $(16x4\sqrt{5})/2$, that is (base x height)/2= area of triangle.

It can be observed in the sample question that student need to know one characteristic of isosceles triangle and Pythagoras Rule which are taught in the treatment.

A second sample question is:

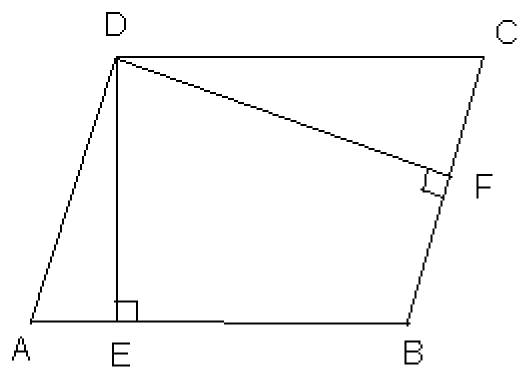

Figure 3.3 A sample question: parallelogram

Figure 3.1 is parallelogram ABCD, in figure [DE] $\perp$ [AB], [BC] $\perp$ [DF], |AB|= 12, |DE|=4 ve |DF|= 6. So what is the perimeter of parallelogram ABCD?

In this question one has to find [BC] in order to calculate the perimeter. Student should know the area rule of parallelogram that is Area = Base x Height. The solution is |AB| x |DE| = |BC| x |DF| as a result |BC|=8 and the perimeter is 2x (8+12) = 40

In the pilot study, GAT was administrated to 65 eleventh grade students in the same school.

Descriptive of item are in Table 3.3.

Table 3.3 Descriptive of pilot GAT scores

	N	Minimum	Maximum	Mean	Std. Deviation
Pilot test	65	2.00	17.00	12.0154	3.03877

As seen in Table 3.3 minimum grade was 2 and maximum was 17. For Anatolian high school students who studied geometry for two years this could be a wide range. The mean of the pilot test was12 out of 18 (SD =3.03877) and this result will be compared with the mean of the students in the experimental study in the discussion section.

ITEMAN program was conducted in order to evaluate item difficulty, item discrimination power and reliability. The ITEMAN program gave information about item discrimination power as a biserial coefficient and item difficulty power as a percentage of correct answers. In this study, the criterion for the item difficulty power is; item difficulty should be between 0.2 and 0.8 (Ebel, 1965 as cited in Crocker & Algina, 1986). The criterion for item discrimination power is; item discrimination power should be greater or equal to 0.2 (Crocker & Algina, 1986). According to the results of the pilot test, all questions satisfied the above criterions, that is item difficulty is in between 0.20 and 0.80 and item discrimination power is greater than 0.20. In addition to the pilot test, item difficulty and item discrimination power of post GAT were analyzed. Items 4, 8, 10, 14 and 18 have item difficulty between 0.20 and 0.40 and items 6, 9 and 11 have item difficulty between 0.63 and 0.76. Items 2, 3, 5, 7, 12, 13, 15, 17, on the other hand, have item difficulty around

0.50. When item discrimination power of post GAT scores was examined, only question 8 had an item discrimination power less than 0.20, -0.13 to be more precise. However the same question has a positive item discrimination power (0.29) in the pilot test. As this item satisfied the criterion in the pilot test and in order to satisfy validity item 8 was kept in GAT. Reliability in the pilot study is 0.60 and it is 0.74 in post GAT.

3.5. Procedure

The literature review began one year before the treatment. Following the literature review at the beginning of 2007-2008 academic year, 9^{th} grade classrooms were randomly formed with the school administration.

GAT, including 18 items, was prepared by the researcher. GAT test was piloted to 65 eleventh grade students and at the beginning of the treatment, GAT was administrated to both groups. Treatment was administered for 6 weeks in both groups. At the end of the treatment, GAT was administrated to both groups. Six weeks following to treatment the retention GAT was administrated to both groups. All three tests were administrated to both groups at the same time.

At the end of the treatment in the experimental group, students were asked to write down their previous group work experiences and to state their opinions on present group work. These opinions were collected by the researcher and the results were presented in the section 3.6.2.

3.6. Treatment

The study was carried out over 6 weeks starting from the beginning of 2007-2008 fall semester in an Anatolian high school in Town A which is a rural town. A total of 44 students, in two mathematics classes were instructed by the same teacher. One of these classes was the experimental group and the other control group. Actually the experimental study was initiated with 45 students 23 in the control group and 22 in experimental group. However one of the students had to leave Town A before the post test. Therefore he was not included in to the analysis. This is also stated in the internal validity section. The experimental group was instructed with hybrid PBL and the control group was instructed with traditional teaching method.

Treatment included the elaboration and study of various mathematical concepts. Pythagoras rule, basic characteristics of right, isosceles, equilateral triangles and area of triangle were covered in the triangle unit. In addition, parallelogram, rectangles, square, trapezoid, hexagon and circle were also studied during the treatment. Special right triangles such as 30°, 60°, 90° and 45°, 45°, 90° were also covered. Basic concern was the area of polygons and circular regions. In order to teach area unit, students in control group and experimental group were taught Pythagoras rule, special right triangles, basic characteristics of right triangle, isosceles and equilateral, areas of triangle at the beginning of the treatment. The instruction was four hours a week.

3.6.1. Treatment in Control Group

The control group was instructed with the traditional teaching method and the treatment consisted of 24 course hours in six weeks. Traditional teaching methods may include many different teaching methods as listed below: (a) teacher lecturing and student note-taking, (b) individual student pen-and-paper practice problems, (c) pen-and-paper assessment, (d) laboratory activities with predetermined outcomes in science classes, and (e) discussions (Morgan, Whorton and Gunsalus, 2000).

The control group was instructed with traditional teaching strategies which included discussions, lectures, and critical questioning. The teacher started the class session with a question related to the topic. Then he let the students to think and answer the question. At the beginning of the experience, about 5-7 students were willing to express his/her ideas on questions. In order to activate most students, the teacher called on not only volunteers but also to other students to express their ideas, give clues etc. Every time a student answered a teacher-elicited question then the teacher asked why the student thought in such a way. After the student defended his/her ideas the teacher let other students comment on the student's answer. Sometimes, he made comments on the solution himself. Discussion usually continued for 10-15 minutes. In those discussions many times, especially in the beginning of 6 weeks period, students tried to answer questions by means of formulas which they had memorized in the previous year in secondary education entrance examination (OKS) preparation centers. In some cases, the formulas were relevant to the structure of the question. However, formulas were irrelevant in some cases. Nevertheless, no matter whether the formula suggested actually helped to solve the problem or not, students were very willing to apply formulas.

At the end of discussion, if students failed to get the result then the teacher spoke about the question for some time. He aimed at getting students to get to a conclusion or remember a fact known before. If the students were not able to make a connection then the teacher directly gave a hint. In addition, the teacher again asked students to comment on the question. Most of the time students found answers following the hints. Nevertheless, if they failed then the teacher answered the question he had asked and let students argue on the question.

Following the first question, the teacher taught the theoretical parts of the unit. In other words, he stated theories and rules. He wrote the theory on the board and waited for students to write it in their notebooks. Following the theory, he asked a similar question which is different in some details and gave the students some time to solve the next exercise. Nevertheless, periods to solve exercises following the first question did not take much time and a student answered the question on the board. Depending on the discussion period of the first question, students solved 4 to 10 questions in a class session. After each question was solved on the board, the teacher asked if anybody could solve the question in an alternative way or if there were other perspectives.

Although questions were solved on the board, some of the students could not comprehend the solution. In this case, the teacher asked another student to restate the solution. Restating solutions promoted students to search for alternative perspectives. Moreover, any student who had a different solution could volunteer to present his/her alternative solution to the teacher and the class.

If the unit to be covered was not familiar to the students then the teacher taught the unit by lecturing. First, the theory part of the unit was stated and following the theory a couple of questions were solved on the board. The students usually comprehended the theory by examples. Therefore, while solving the question on the board, the teacher talked about the solution of the question and then waited for the students to write the question in their notebooks. Following this, the teacher stated the solution once more. Hence, a couple of questions were solved twice on the board. Giving the theory and solving a couple of questions took about 20-25 minutes. After this period, teacher usually presented some exercises to the students.

In the discussion period, the teacher tried to manage his time effectively. That is, he increased time of discussion periods in some critical questions by asking more detailed ones whereas he ended discussions after a short while on some typical questions. It usually depended on the importance of the unit involved.

The teacher did not force students to participate in activities such as collecting data, gaining new knowledge, and studying before a classroom period. However, after class, each student was responsible for completing homework assigned by the teacher. The homework was related to the topic which was studied in the classroom. In the first week of class, the teacher strictly checked homework whereas in the following weeks he sometimes checked completion of assignments. Homework was generally done by students. The homework contained 12-20 questions on each topic (basic characteristics and area of right, isosceles and equilateral triangle, parallelogram, rectangle, square, trapezoid, hexagon and circle). All the questions within the assignment were elaborated on in class one by one. That is, the teacher asked the students whether each question was solved or not. If a student could not do a question then s/he asked the teacher for help to solve the question. The teacher asked if any volunteer could solve the problem. For most questions, the teacher asked a second student to revise the solution.

The main problem of every two hours session was difficult to solve in a short time. Although few students could observe crucial points in first questions, the following questions were familiar to most of the students. If they had a solution for the problem then they came to the teacher one by one and showed their answer. The teacher awarded students effort by awarding pluses (+). These pluses would be converted to a general score at the end of the semester. He also awarded less achiever by asking simpler questions. At the end of two weeks, all students in the classroom had some pluses. In each two hour session, students counted their pluses on the list. Pluses were very important for them and it was like a race between students.

At the end of the fifth week, the control group was given homework with 16 questions. The questions were chosen in the resources which are parallel to both experimental groups and control group's studies. In the 6^{th} week, these questions were solved and the groups reviewed their learning for the 6 week period. During the treatment, the topics covered in control group were the same as the experimental group. The lesson plan about areas of triangles is in Appendix E. There are some sample questions in the sample plan.

3.6.2. Treatment in Experimental Group

The experimental group received instruction with hybrid PBL and the treatment continued for 24 course hours in six weeks. As indicated beforehand, hybrid PBL is often used as an entry point into PBL in the course transformation process. Problem-driven learning is used non-exclusively in a class and a hybrid model may include separate lecture segments or other active-learning components. There are many types of hybrid models including mini-lecture if needed, whole class discussion, preparation of group product, group discussion, research, exams and other formal assessment, and writing (Smith, Sheppard, Johnson, & Johnson, 2005).

In the experimental group, at the beginning of the treatment, six groups were formed. There were 4 students in 4 groups and 3 students in 2 groups. In order to form groups, previous year mathematics grades of students and their mathematics scores in secondary education entrance examination (OKS) was listed. The groups were formed in a way that students in different academic performance and gender could interact. There were 9 girls in the classroom. Therefore there were 2 girls in 3 groups and 1 in 3 groups. Heterogeneity of the groups was maximized based on their mathematics grades and OKS mathematics scores. The students studied in the same groups for all 6 weeks.

After groups were formed, the teacher explained to the students about what they were expected to do in their group studies. The teacher requested students to listen to their group members' ideas, to respond to questions and work together with their group members during all activities and he requested them to share ideas and solutions with their group members. They were not given information on PBL in order to avoid any threats such as attitudes of students.

The main problem was introduced in a very natural sequence. First of all, needs of town A were discussed. Students usually complained about lack of sports facilities and interesting places to enjoy time. Then the teacher asked about the necessity of a park in Town A. Many students agreed that town A needed a park with entertaining places and sports facilities in it. Following this agreement, the teacher asked the students how a mathematician would create a park and introduced the first part of the main problem to the students. This problem is 'Town A is a touristic county. People come to town A because of its natural beauty and thermal facilities. Nevertheless, in Town A there is no park in which people can walk, have a rest, and participate in some facilities. So you, as a mathematician, are responsible for preparing a roughly drawn plan of 'Town A Geometry Park'. In this park, every part of any building and construction has to be in a geometrical shape such as a triangle, parallelogram, rectangle, square, trapezoid, hexagon and circle. You will meet a landscape architect to have an idea about how to draw a plan and about components of a geometry park. '

In order to prepare students for the second part of the problem, mentioned below, the teacher also requested all groups to state the rules of calculating areas of geometrical shapes in the project on a paper, calculate areas of elements in the roughly plan the geometry park and write it down on the plan for the next two hours. The students asked area formulas of polygons to the teacher. As a part of the treatment the teacher did not give the formulas. Instead, he recommended some resources and text books of 10^{th} and 11^{th} grade geometry books which were recommended by Ministry of Education.

Two of the groups decided that all group members should study all regular geometrical shapes in the project which are triangle, parallelogram, rectangle, square, trapezoid, hexagon and circle. The rest of the groups decided, on the other hand, to share responsibilities. For instance, member A and B would be responsible for studying formulas and characteristics of triangle and teach it to rest. Then some others would be responsible for another unit.

After the problem was introduced, in the second hour, the teacher asked the students to think about the components of the geometry park. Meanwhile, a sheet was distributed to all groups namely ‘A ilçesi Geometri Parkı Projesi’ (See Appendix D). In this sheet, general rules and expectations were listed. In the same hour each group was requested to make a group task plan in order to complete the rough drawing of the geometry park in 6 school hours. In the Group Task Plan (See Appendix G) students planned duties of group members, buildings and facilities in the geometry park, meeting times and drew up a schedule of the steps and dates of the project. They were also asked to meet at times other than class hours and complete the drawing of the geometry park.

Following the first two hours, the teacher met a landscape architect who worked for the municipality of Town A. The teacher explained to the architect about the project and expected gains of the students. Then he requested the architect to encourage students to make a plan of the geometry park, give them some ideas and give detailed information about his job. The following day, the architect came to the school and met the students. In the meeting, students asked some questions and the architect answered the questions. Furthermore, he gave some detailed information about his job. For example, he gave some clues about how an architect draws a plan. The meeting lasted for 50 minutes. The students seemed very impressed and motivated for the project after the meeting.

In the second hour of the class period, every group determined elements of the geometry park. In this period as it was expected, extroverted students were more active, more willing to take responsibility in groups and they were behaving like group leaders. In this part of the activity, students studied with their group members and the teacher talked to every group and asked questions about their process.

The students were requested to complete the rough plan of the geometry park in 6 hours. Only one of the groups finished the task in time, it took 8 hours for other groups to finish it. Although there were particular reasons for each group, the most important difficulty, the groups had, was that the groups did not obey the timetable they had drawn up. They had not been able to meet at times planned before and they failed to complete their duties in time for meetings. Actually, most times the groups did not meet as a whole group. In each period, the teacher asked the members of all six groups if they had obeyed the group task plan and if they had met in groups all the time and he took notes about student's behaviors. Although all students were enthusiastic in studying in such a project, they were reluctant to obey group decisions and timetable. Only one of the groups totally obeyed their timetable. In this group, a harmony could be observed both in the classroom and out of the classroom. This group completed their rough plan in six hours. On the other hand, as a result of weakness to obey meeting times, the teacher had to force the other five groups to accelerate their projects. Therefore, in these five groups some of the group members completed missing parts instead of their group members. Students, who undertook their groups' members' duties, did not complain to the teacher. However, the tension within the groups could easily be observed.

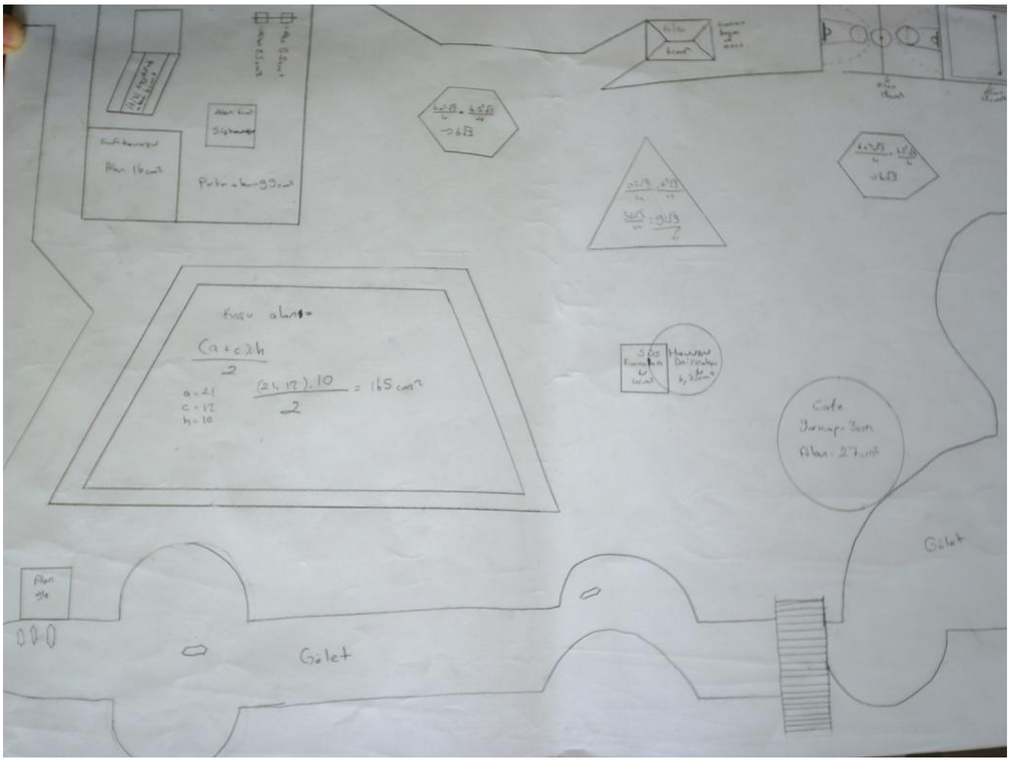

Figure 3.4: A rough plan of the geometry park

In the 8^{th} hour every group made a small presentation on their geometry park, geometric elements in it, facilities and reasons of why they choose these facilities. After each plan, the teacher initiated students to rate presented plans. The students rated all plans in margins 8-10 out of 10. This was an entertaining activity and all students had fun.

As the students finished drawing their geometry park, it was time to introduce the second part of the problem. Teacher asked all groups, one by one, how they calculated the area of elements in the geometry park. Then, he asked the groups about the area of the same element by changing its properties. For example, the teacher talked to a group about a picnic place, shaped in an equilateral triangle, in their plan and he asked them how they would calculate the area if it was shaped in a right triangle. At the end of this activity, the groups observed that they were good at calculating areas of the geometrical shapes with some properties. On the other hand, they could not calculate the area when some properties of the same element were changed. Then, the teacher introduced the second part of the problem: 'you have to study area formulas again but this time you should consider that a geometrical shape could have different properties and you should be able to calculate its area when we chance its properties. For instance, you should be able to calculate the area of a triangle whether it is an isosceles, equilateral or a right triangle. In order to focus on area unit deeply you will make presentations in the classroom and discuss about area unit in the classroom. All of you should study on each area unit existing in your plans and each group will present one unit. You will also solve some examples on the intended area unit in your presentations. During this activity please share responsibilities with your group members. Please do not forget you are mathematicians and you will show us how you do mathematics.'

The students were successful in calculating areas of elements in their plans and the teacher aimed for all students to have more knowledge on polygons and circular regions so that they could calculate the same element when its properties were changed. The teacher intended students to realize the existence of rules and facts in the units and to be able to calculate the area of polygons and circular regions existing in the national geometry curriculum. The teacher declared that the groups would not be able to choose the unit to present; instead units would be delivered randomly. In the 9th hour the area units were delivered to groups and dates of presentations were also stated. The subjects and their order of presentations were: 1-triangle, 2-parallelogram, 3- rectangle, square, 4- trapezoid, 5-hexagon and 6-circle. Triangle unit contained basic characteristics of isosceles, equilateral right triangle and area formula of triangle. The intended basic characteristics of equilateral triangle can be stated as ‘all sides and all interior angles of equilateral triangle are equal’ and ‘a height of an equilateral triangle divides the base in to two equal parts’. The intended characteristic of isosceles triangles is ‘a height of an equilateral triangle divides the base into two equal parts’ as shown in Figure 3.5. Pythagoras rule and characteristics of right triangles 30°, 60°, 90° and 45°, 45°, 90° were also included. In the other units area formulas and perimeters were included.

All groups were expected to act as if they were a teacher. The presenting group prepared a lesson plan together with the teacher two days before the presentation. The teacher asked all groups to demonstrate their preparations to him two days before the actual class presentation. In this demo-presentation, students presented their units and solved questions. Students behaved as if they were teaching in the classroom. If the teacher was not satisfied with the preparations, he stated the missing parts and another presentation was held the following day. If students still failed in some parts, teacher helped only in these parts. However, students rarely failed to perform as expected at the end of second meeting. In total, one group was well prepared in the first presentation and the teacher did not meet them for the second time; on the other hand, the other five groups had to present twice.

In this part, the students were requested to bring resources of geometry to class and use them as a reference in their studies at the beginning of the third week. Only two of the six groups brought related text books. Although all students had decided to bring text books for this week, some of them did not. The teacher asked their reasons; however, the students failed to respond. Although, he lent them his text books, he declared that he would not do this again. What is more, groups did not seem well prepared about the characteristics and area formulas of geometrical shapes. As a result, some groups had small conflicts and discussions. Hence, this assignment was delayed to the 9th hour. In this hour, most groups were ready and they shared the characteristics and the formulas in their groups.

In the last two hours of the third week presentations was initiated. In groups students shared duties. Such as one of them would start teaching period, one of them would final teaching period, one of them would answer questions and finally one of them would prepare homework and check students' responses to these questions in homework.

In all groups, it was observed that students researched some resources of geometry. They first asked their teacher questions such as which book was 'easy to understand', 'available to borrow', and 'has many examples'. In addition, they interrogated the more senior students at school. They borrowed books mainly from other students in the school. Some of them asked their teacher to lend some books. They first studied subject matter by help of the text books and then shared their findings with their group members. As, it had occurred in previous parts of the experimental study, students sometimes failed to meet in time.

In the third week, the first group designed their presentation in such a way that they noted one characteristic of a triangle and gave an example respectively. This seemed to be the method of their previous mathematics teachers. Interestingly, after the first presentation the other groups behaved in the same way. The examples they solved were chosen from recourses which were usually prepared for university entrance examination (ÖSS). The questions in these books were parallel to the curriculum. The exercises in these books were not real life problems. Nevertheless, it should not be forgotten that the reference point of their presentations was their geometry park plan. The students prepared such examples and questions because they wanted to answer the question of 'how we can calculate the area of the same geometric figure when its properties are changed?'

Following the presentation on the triangle, the responsible group prepared 10 questions on triangles. Then, the teacher offered to create a competition between groups. All students accepted the offer. The teacher explained the rules of the competition. Three minutes would be given for each question and if more then one group answered the question, the group who solved the question on the board would be chosen by a draw. Lastly, students who would solve question on the board would be chosen randomly. The race was very enjoyable. The group members were exited and most of them behaved like a team for the first time. In the forth, fifth and sixth weeks, races were held in order to increase group interaction.

In the teaching period, other students were motivated in asking questions. The classroom atmosphere was relaxed and they liked to ask questions to their friends. However, there was a disadvantage of this teaching period. If the presenting group made a mistake, the other students usually did not realize it. In this case, the teacher interrupted the presentation and tried to direct the student to realize mistakes by asking questions. This part of treatment was time consuming.

During the treatment in experimental group, discussions occurred very naturally. As the presenters were their friends, they seemed confident to ask questions and to comment on the unit. The discussions mainly happened by interrupting the presenter. Whether the presenter gave information about theory part or solving a question, students usually interrupted the presenter and initiated a discussion session. The presenting groups were sometimes exited in their discussions and they became very happy when they were able to answer questions. In discussions, if a group member could not answer the question or could not comment on the concern, then other group members tried to do so. It was enjoyable to see them working together even though the discussion sessions were a little bit noisy.

Discussions in classroom were not independent of the teacher. Actually, after discussions, they automatically made eye connect with the teacher. The reason for this phenomenon was usual because it was easy for them to make mistakes. If the students in the classroom could not initiate a discussion then the teacher asked a question on the topic of concern. For example: in the beginning of triangle unit, the presenter drew an isosceles triangle on the board and stated the rule:

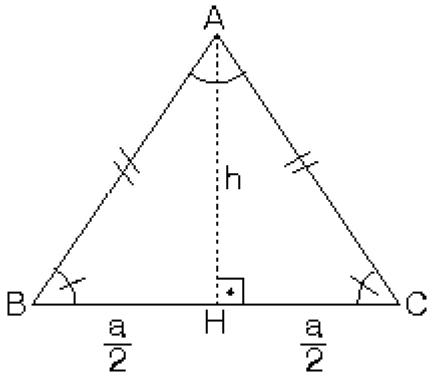

Figure 3.5 A characteristics of isosceles

‘In isosceles triangle, the height divides the base of triangle into two equal parts’ the students drew the figure and wrote the rule on their notebooks. It was the first week of presentations and the students usually wrote statements on their notebooks. The teacher turned to the class and warned them ‘If I were you, I would ask why the height divided the base into two equal parts’. Then, ‘why’ questions were very popular in discussions.

In the forth week, area of parallelogram, rectangle and square was presented. In these presentations, groups followed the teaching method that the first group had applied. In the last hour of the week, groups, themselves prepared a competition with their own questions. During the competitions, students who stated critical idea were rated by teacher. Rewarding student’s efforts motivated them very much. The groups regularly brought their textbooks and notes regularly. As time passed, the groups studied in increasing harmony. The conflicts in the groups minimized as they were experienced.

In the fifth week, three groups presented the trapezoid, hexagon and circle. In these learning periods two of the groups shared their responsibilities very fairly. Everyone in these groups was involved in one of the parts of their duty. Actually, they became teams, which is an expected feature of PBL. Moreover, except for the week students delayed the plan of the geometry park, the group interaction, classroom discussions and presentations occurred in a relaxing atmosphere. However, the classroom was noisier than the control group and sometimes some students complained about the noise.

At the end of the fifth week, both the experimental group and the control group were given homework with 16 questions. The questions were chosen in the resources which are parallel to both experimental groups and control group's studies. In the 6^{th} week these questions were solved and the groups reviewed their learning. In the last hour, each group studied independently and mainly high achievers helped their group members to solve questions or comprehend any point. A lesson plan for experimental group is in appendix F.

At the end of this section it is worth to declare students' opinions on cooperative design because group harmony is a very important reason which can affect the outcome of the study. In order to reflect on group work effect, students were asked their ideas on cooperative design at the end of the treatment. In the experimental group, 13 students mentioned that cooperative work was enjoyable, 2 of them complained about the noise, 2 students reveal that they skipped some important parts of task because of group activity, 5 students complained on group members who did not complete the task and 7 students stated that their group could not meet regularly. Lastly, 4 students were completely against group activities. The effects of cooperative design will be discussed in discussion section.

3.7. Analyses of the Data

The following procedure was used to analyze the data;

- Students' GAT scores of pre-test, post-test and retention were transferred to computer environment by SPSS
- Data of the study were analyzed by SPSS
- Descriptive statistics were used to get the means, standard deviations etc. of the students' GAT scores and to find the rates of socio economic indicators of students
- Recorded data was checked in order to detect outliers (data cleaning).
- In order to determine whether there was significant mean difference among students with respect to their GAT scores, the results of pre-test, post-test and retention were used. Independent t-test and repeated measures one-way ANOVA

were the parametric ones and Mann-Witney U test was the nonparametric one. Independent t-test compared retention test scores of the experimental and control group. Repeated measures one-way ANOVA compared the means of experimental group which received hybrid PBL across three time periods. As pre-test and post-test scores of control group normality assumptions were violated, Mann-Witney U test was used to compare pre-test and post test scores of the control group and experimental group.

- The probability of doing a Type I error, α was set to be 0.05.

3.8. Assumptions and Limitations

In this section, assumptions and limitations of the study are presented.

3.8.1. Assumptions

1. The teacher was not biased during the treatments.
2. Geometry Achievement Test was administered under standard conditions.
3. Students answered test questions seriously.
4. Students in control and experimental groups did not interact with each other.

3.8.2. Limitations

The researcher was the teacher in both the experimental group and control group. If the researcher had been the observer instead of the teacher, the research result might have been more reliable. At the beginning of the study, the researcher suggested many mathematics teachers to work together in such a study in Town A; however, he could not persuade any mathematics teacher for such a tiring and long period.

The subjects of this study were limited to 44 ninth grade students at an Anatolian high school in Town A during 2007-2008 fall semesters. The students' learning ability, learning experiences, outcomes, typical behaviours and their expectations may not reflect the typical students enrolled in other schools in Town A or in other parts of Turkey. As a result, outcomes of the thesis may not be reliable to generalize beyond students enrolled in a different situation. In addition to this, this study was limited to geometry units existing in GAT.

3.9. Internal and External Validity

In this section, the internal and external validity of the present study will be discussed.

3.9.1. Internal Validity

The internal validity indicates whether any findings observed among the results are only due to dependent and independent variables, not due to some other unintended variable (Fraenkel & Wallen, 1996).

In this study, students were randomly distributed to experimental and control groups. In addition to this, the experimental group and control group were chosen randomly. As a result of randomization, subject characteristics of the students were not a threat in this study.

Attitude of the subjects was not a threat for this study because the groups did not know what the other group was doing. Both groups supposed that they were being taught geometry in addition to regular curriculum.

Loss of subject was not a threat for this study because the study started with 45 students and one of the students in the control group had to leave school. He did not take post and retention tests. As a result he was not included in the analysis. In addition to this, one of the students in the control group left school after the post test;

therefore, he was included in the analysis of pre-test and post test and he was not included in the analysis of retention.

Location was not a threat for this study, because GAT was applied as pretest, posttest and retention test to both groups at the same time and physical conditions of classrooms were almost the same for both groups.

Implementation was not a threat for this study because homework and tests solved in experimental group and control group were the same. Moreover, in order to prevent an implementation effect, open-ended questions were not asked which possibly would be a bias for experimental group.

Instrumentation was not a threat in this study. The teacher, teaching in both experimental and control group, was the researcher of this study; hence, there was a data collector bias possibility. The conditions such as homework and instruments were exactly replicated in both groups. On the other hand, testing was a threat for this study as a pretest was applied to both groups.

3.9.2. External Validity

External validity refers to the results of a study that can be extended to groups and environments (Fraenkel & Wallen, 1996).

In the present study, the sample size was small; therefore, the generalizations of the findings of the study were limited. Hence, the results can only be generalized to the students with the same characteristics which were mentioned in the 'subject of the study' section.

Additionally, the classroom settings were regular classroom setting of 9^{th} grade classes; therefore, generalizations can only be made with classroom setting of similar features.

CHAPTER 4

RESULTS

In this chapter, the results of the study are explained. These results include statistical evidence for the claims of the study. There are three sections in this chapter. These are: descriptive statistics, inferential statistics and conclusions of the study.

4.1. Descriptive Statistics

In this section the descriptive statistics of the data are given. Table 4.1 shows the means and standard deviations, maximum and minimum values of pre, post and retention GAT scores.

Table 4.1 Means, standard deviations, maximum and minimum values of GAT scores

Groups	Statistics	Pre-test	Post Test	Retention Test
Control	Mean	3.05	9.36	7.10
	Std. Deviation	2.554	2.804	3.727
	Minimum	0	0	0
	Maximum	9	12	14
	N	22	22	21
Experimental	Mean	3.82	8.50	8,00
	Std. Deviation	2.938	3.569	3.916
	Minimum	0	2	1
	Maximum	10	15	15
	N	22	22	22

As seen in the table 4.1, although means of pre-test scores of experimental group is slightly higher than that of control group, means of post test scores of control group is higher than that of experimental group. On the other hand, means of retention test scores of experimental group is higher than that of control group. In general, mean scores are low out of 18 questions. The differences will be examined statistically in the analysis below.

4.2. Results of Inferential Statistics

In this section, the sub-problems of the study will be examined by means of their associated hypotheses which are in the null form and tested at a significance level of 0.05.

4.2.1. Results of Testing of the First Main Problem

The main problem of the study is "What is the effect of the problem-based learning method on ninth grade students' geometry achievement?". The first sub-problem of the study is "Is there a statistically significant mean difference between students instructed with traditional teaching method and those instructed with problem-based learning with respect to geometry achievement?". Its hypotheses are as follows:

$H_0$1.1: There is no statistically mean difference between students instructed with traditional teaching methods and those instructed with problem-based learning with respect to post geometry achievement.

$H_0$1.2: There is no statistically mean difference between students instructed with traditional teaching methods and those instructed with problem-based learning with respect to retention in geometry.

Normality and the equality of variance assumptions were tested. The results of the first assumption are presented in Table 4.2

Table 4.2 Test of normality for GAT scores

Tests	Group	Kolmogorov-Smirnov		
		Statistic	N	Sig.
Pre-test	Control	0.204	22	0.018
	Experimental	0.155	22	0.182
Post test	Control	0.272	22	0.000
	Experimental	0.163	22	0.134
Retention	Control	0.139	21	0.200
	Experimental	0.146	22	0.200

As seen in Table 4.2, while pre-test and post test scores of control group normality assumptions were violated ($p<0.05$); its retention test score was normally distributed ($p>0.05$). Three test scores of experimental group satisfied the normality assumption. The equality of variances was tested by Levene's test. The results are given in Table 4.3

Table 4.3 Levene's Test Results for Three GAT scores

Tests	F	Sig.
Pre-test	0.450	0.506
Post test	2.573	0.116
Retention test	0.243	0.624

As seen in Table 4.3 assumptions on equality of variance were satisfied for pre-test, post test and retention test ($p>0.05$).

The hypothesis of the first sub-problem was "There is no statistically mean difference between students instructed with traditional teaching methods and those instructed with problem-based learning with respect to post geometry achievement." This hypothesis was tested by Mann-Witney U Test because the normality assumption of post-test scores was not satisfied. Before testing this hypothesis the equivalence of the groups were tested. The results are given in Table 4.4

Table 4.4 Results of Mann-Witney U Test for Pre-test

Variable	Groups	Mean Rank	Mann-Witney U	p
Pre-test	Control	20.73	203.000	0.356
	Experimental	24.27		

Table 4.4 indicates that there is no statistically significant mean rank difference between students instructed with traditional teaching method and those instructed with PBL method with respect to pre-test scores ($p > 0.05$). It could be accepted that these two groups were equivalent in terms of GAT achievement at the beginning of the treatment (Mean $Rank_{CG}$= 20.73 and Mean $Rank_{EG}$ =24.27).

The first hypothesis of the first sub-problem was tested by using Mann-Witney U Test because of the results of assumptions and comparison of pre-test score. The results are presented in Table 4.5

Table 4.5 Results of Mann-Witney U Test for Post Test

Variable	Groups	Mean Rank	Mann-Witney U	Sig.
	Control	24.14	206.000	0.394
Post test	Experimental	20.86		

Table 4.5 reveals that there is no statistically significant mean rank difference between students who were instructed with traditional method and those instructed with PBL with respect to post test scores ($p > 0.05$). However, the mean rank of pre-test scores of the control group is greater than their mean rank of pre-test scores of experimental group (Mean $Rank_{CG}$= 24.14 and Mean $Rank_{EG}$ =20.86).

The second hypothesis of the first problem was “There is no statistical mean difference between students instructed with traditional teaching methods and those instructed with problem-based learning with respect to retention in geometry.” Its assumptions were tested. All assumptions were satisfied so that it was tested by using t-test. The results are given in Table 4.6

Table 4.6 Independent t-test for retention test

Variable	Group	Mean	SD	T	Sig.
	Control	7.10	3.727		
Retention				-0.775	0.443
	Experimental	8.00	3.916		

As seen in Table 4.6, it was found that there is no statistical mean difference between students instructed with traditional teaching methods and those instructed with problem-based learning with respect to retention in geometry ($p>0.05$). However, the mean of control group was slightly less than the mean of experimental group with respect to retention test score ($Mean_{CG}= 7.10$, $SD_{CG}= 3.727$; $Mean_{EG}= 8.00$, $SD_{EG}= 3.916$). In addition to mean scores, mean rank scores were also computed. The mean rank of pre-test scores of control group was less than their mean rank of pre-test scores of experimental group ($Mean\ Rank_{CG}= 20.45$ and $Mean\ Rank_{EG} =23.48$).

4.2.2. Results of the Second sub-problem

The second sub-problem of the present study is "Is there a statistically significant change in the Geometry Achievement Test scores of the students instructed with problem-based learning across three time periods (pre-treatment, post treatment and retention)?" Its hypothesis was "There is no statistically significant change in the Geometry Achievement Test scores of students instructed with problem-based learning across three time periods (pre-treatment, post treatment and retention). It was tested by Repeated Measures One-way ANOVA at the significance level 0.05. Normality and equality of variance assumption were satisfied. Furthermore, assumption of sphericity was also satisfied (Mauchly's W=0.801, df=2, p=0.109). The results of analysis are given in Table 4.7

Table 4.7 Results of one-way repeated measures ANOVA for GAT scores of PBL group with respect to time

Effect	Value	F	Sig.	N	Partial η^2	Observed Power
Wilk's λ	0.219	35.657	0.000	22	0.781	1.000

As seen in Table 4.7, it was found that there was a significant effect for time (Wilk's lambda=0 .000, F(2, 22) =35.657, p= 0.000). The partial eta-squared was found as 0.78. This result suggests very large effect size by utilizing guidelines proposed by Cohen (1988). To find out which pairs of time periods caused the mean difference scores of GAT, least significant difference (LSD) comparisons were used. The results are presented in Table 4.8.

Table 4.8 Pairwise Comparisons of GAT scores of students in PBL group

(I) time	(J) time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
1	2	-4.682	0.544	0.000	-5.813	-3.550
	3	-4.182	0.580	0.000	-5.387	-2.976
2	3	0.500	0.382	0.205	-0.295	1.295

As seen in Table 4.8, a statistically significant mean difference between pre-test and post test scores in the favor of post GAT scores was found (Mpre=3.82, SDpre=2.938; Mpost=8.50, SDpost=3.569). The mean score of retention test was statistically significantly higher than the mean score of pre-test score (Mret=8.00, SDret=3.916). However, it was also revealed that there was no statistically significant mean difference between post test and retention test scores.

4.3. Conclusions of the study

In the light of the results obtained by examining the hypothesis, the following conclusions can be stated:

1. There is no statistically mean difference between students instructed with traditional teaching methods and those instructed with problem-based learning with respect to post geometry achievement.

2. There is no statistically mean difference between students instructed with traditional teaching methods and those instructed with problem-based learning with respect to retention in geometry.

3. There is a statistically significant change in Geometry Achievement Test scores of students instructed with problem-based learning across three time periods (pre-treatment, post treatment and retention).

CHAPTER 5

DISCUSSION, IMPLICATION AND RECOMMENDATIONS

This chapter is comprised of a discussion, implications and recommendations for further studies. The first section includes restatement of some results and discussion of these results in the study. In the second section implications are stated and lastly some recommendations for further research studies are put forward.

5.1. Discussion

The purpose of this study is to answer, what is the effect of problem-based learning on ninth grade students' geometry achievement? The independent variable is the type of teaching method used in classroom instruction: PBL or traditional teaching methods. The dependent variable is student achievement as measured by the difference in pre-GAT, post GAT and retention GAT score.

In this study, before the treatment, the GAT was administered to students both in the experimental and the control groups to determine whether two groups differed with respect to the collective dependent variables of the study. Statistical results revealed that there were no preexisting differences between the two groups with respect to students' achievement in geometry, mainly in the unit of areas of triangle, parallelogram, rectangle, square, trapezoid, hexagon and circle.

During the treatment, the experimental group was instructed in light of hybrid PBL while students in control group received traditional instruction. Results indicated that these two groups were equivalent in terms of geometry achievement at the beginning of the treatment (Mean RankCG= 20.73 and Mean RankEG =24.27). Following six weeks treatment, the post test was applied and there was no statistically significant mean rank difference between students who were instructed with the traditional teaching method and the hybrid PBL with respect to post test scores. On the other hand, the mean rank of post test scores of the control group is greater than that of the experimental group (Mean RankCG= 24.14 and Mean RankEG =20.86). The retention test results were parallel to the two preceding results; there is no statistically significant difference between students instructed with the traditional teaching method and students instructed with the hybrid PBL. However, the mean of retention scores of the control group is less than that of the experimental group (M_{CG}= 7.10, SD_{CG}= 3.727 and M_{EG}=8.00, SD_{EG}= 3.916).

Following the statistical meanings of the tests, it is worth comparing the means of the experimental and control group in three tests. Means of pretest means scores of the experimental group is slightly greater than that of the control group (M_{CG}= 3.05 ,SD_{CG}= 2.554; M_{EG}= 3.82, SD_{EG}= 2.938). On the other hand, posttest statistical results indicated that the control group's GAT scores are much higher than that of the experimental group. As indicated beforehand in the limitations section, number of participants in the control group and experimental group can have prevented reflection of the difference into a statistical meaning. That is, if there had been more students in both groups, there would have probably been a statistically meaningful difference as a result of post test.

An important point while examining the post test means is the level of scores out of 18. The means of 44 students in the experimental study is 8.93 according to post GAT scores. Hence, the reasons for the low scores need to be discussed. First of all, we have to compare the means of post test results by that of the pilot test. The mean scores of 65 students in the pilot test are 12 (SD= 3.03877) as presented in Table 3.3. Out of 18 questions 12 mean is an acceptable level.

In a regular high school program, triangle and polygon geometry is taught in 10^{th} and 11^{th} years. 10^{th} grade geometry is mainly about triangles and 11^{th} grade geometry program is about other polygons and circular regions. The area unit exists in some parts in both 10^{th} and 11^{th} grade geometry programs. In this two year period, students' geometry ability improves gradually. In this study, the area unit of a two year program was brought together and an easy part of it was taught to the students. Hence, it would be worth conducting a similar study for a longer period. Such a study may gradually increase students' geometrical abilities which may result in higher means in post GAT. Besides the content derived during the study could be reduced. Some parts of polygons need not have been taught. If the duration of the teaching period increased for each of the polygons and if the exercises solved in both groups increased, mean scores in both groups would have possibly increased.

In addition to all the arguments about the mean scores ($M=8.93$, $SD= 3.336$) of students in the experimental study, Gulliksen (1945, as cited in Crocker & Algina, 1986) states that in order to maximize total score variance, and hence reliability, item difficulty should be medium, that is 0.50. According to Gulliksen's criteria, mean scores should be 50 out of 100. As a result 9 out of 18 is not low for this test.

The retention test was applied 6 weeks after the treatment. Although there is no significant mean difference between the control group and experimental group, means of retention GAT scores are also parallel to the literature in some degree. Norman and Schmidt (1992) stated that, compared to traditional lecture forms, PBL may direct to better retention of knowledge after some weeks up to years. This result is also true when the post test of PBL group is weaker than that of the group instructed with the traditional lecturing method. The situation is the same in this study. According to post test results, the traditional teaching method group is more successful than PBL group ($M_{CG}= 9.36$, $SD_{CG}= 2.804$; $M_{EG} =8.50$, $SD_{EG}=3.569$); besides, PBL group is more successful in retention test ($M_{CG}= 7.10$, $SD_{CG}= 3.727$ and $M_{EG}=8.00$, $SD_{EG}= 3.916$). It is valuable to examine the means indepth. During six weeks, the control groups' mean score reduced 2.26 (9.36-7.10 = 2.26). During the same period, the mean scores of experimental group reduced only 0.50 (8.50-8.00=0.50). This difference is valuable. PBL group conserved their achievement for six weeks after the treatment. On the other hand, traditional teaching method group lost an important degree of their gain.

In the literature, superiority of PBL in retention is widely accepted, and in this study there is a difference. On the other hand, the difference is not statistically significant. There may be two reasons for this. In the literature, PBL is mostly compared with the traditional lecturing based teaching model. Differently in this study, the aim was to enhance the traditional teaching model by incorporating different communication models such as lecturing and many exercises. This technique in traditional teaching method could create a difference with the studies in the literature. Secondly, 6 weeks after treatment may not be a good time for retention test. If the retention test had been implemented maybe 3 months after the treatment, we would have possibly had a statistically significant difference between the two groups. In the literature of PBL studies, there is no specific time for the implementation of a retention test. As Norman and Schmidt (1992) stated, PBL may direct to better retention of knowledge after some weeks up to years.

PBL environment is usually constructed mainly by cooperative learning. Indeed, cooperative problem-solving groups are a key feature of PBL (Hmelo-Silver, 2004), and parallel to the literature, 6 groups were formed in the PBL group. At the beginning of the treatment in the experimental group, students were asked if they had participated in group work in their previous learning experiences. Eight students revealed that they had worked in groups in the classroom for short periods such as one or two hours in activities like handicrafts. The rest of the experimental group had not experienced group work or could not remember if they had.

As a result of lack of experience in cooperative work style, all groups had many problems. The most frequent obstacle was meetings. As mentioned in the treatment section, all groups had a group task plan for their duties. In order to complete their duties in time, all groups had to meet in some periods planned in the timetable. However, some group members rarely came to the meeting. Although, all students were enthusiastic to study in such a project, some of the students were reluctant to obey group decisions and the timetable. Only one of the groups totally obeyed their timetable. Therefore, regular students had to complete all the work. In the experimental group, 13 students reported that cooperative work was enjoyable, 2 of them complained about noise, 2 students revealed that they skipped some important parts of the task because of group activities, 5 students complained about some group members who did not complete their tasks and 7 students mentioned that their group could not meet regularly. Lastly, four students were completely against group activities.

One of the well known effects of problem based learning is improvement in self regularity (Perry, Vandekamp, Mercer, & Nordby, 2002). PBL enhances the self-regulatory skills of students (Galand, Bentein, Bourgeois, & Frenay, 2003). As a result of the literature about self regularity, students were expected to become effective cooperative learners. However, there were some complaints of students about group work in this study. They mainly complained about irresponsible group members. As mentioned before, none of the students in the experimental group had participated in group work for such a long period. This reason may have affected the achievement in a negative sense. Thus, to overcome such a reason in an experimental study of PBL, groups can be formed some time before treatment. As a result, students may get accustomed to working in groups, and may learn to share responsibilities.

In all, the above argument is about comparison of PBL and traditional teaching. In this study, the impact of these two instructional methods on students' achievement is not statistically different. Nevertheless, this result should not hide the reality that PBL has a positive effect on students' achievement. As it is stated in the second sub problem, there is a significant mean difference between pre-test and post test scores of the PBL group. This result is not surprising because students had six weeks treatment. What is more important is that there is no significant mean difference between post test and retention test scores of the PBL group. This point indicates PBL's powerfulness. PBL helps students to retain achievement (Duch, Groh, & Allen, 2001; Gordon, Rogers, Comfort, Gavula, & McGee, 2001; Norman & Schmidt, 1992).

To sum up, there is no statistically mean difference between students instructed with PBL and those instructed with traditional teaching methods with respect to geometry achievement. On the other hand, PBL has a positive effect on students' achievement in geometry. In addition to this PBL may contribute to students' retention of achievement in geometry.

5.2. Implications

In this section implications of the study are stated for teachers, curriculum developers, and teacher educators by taking into account the findings of the study and the researchers' experience and observation during the hybrid PBL instruction.

Teachers :

Teachers tend to complain that students forget rules, theory and knowledge very fast. They may think that knowledge given to students is the center of students' lives. Students, on the other hand, usually forget knowledge after examinations. This study suggests that PBL may contribute to students' retention of achievement and hence, teachers should focus on PBL which may result in long lasting learning. Thus, Teachers should learn PBL by themselves or by attending in-service training programs. It should be noted that Turkish Ministry of National Education (MoNE) developed the secondary education mathematics curriculum which requires teachers to use PBL in their courses (MoNE, 2005). Thus, this book and similar studies can provide opportunities for teachers to be competent on using PBL.

Curriculum developers:

The findings of the present study that retention was supported by PBL has significant results on the follow up tests (Dochy, Segers , Bossche, & Gijbels, 2003; Norman & Schmidt, 1992). PBL can contribute students to retain knowledge. Thus, curriculum developers should emphasize on how to use PBL in mathematics courses effectively. For example, they can give sample activities on PBL so that teachers and book authors can use PBL in mathematics courses/books.

Teacher educators:

In order to contribute to students' retention of knowledge which is related to real life, PBL may be a beneficial learning/teaching method. Teacher educators may conduct PBL in their courses instead of teaching this concept in their courses. As a result, pre-service teachers are likely to learn important issues in PBL and gain experience in its implementation.

5.3. Recommendations for further studies

The subjects in this study were ninth grade students in an Anatolian high school in a rural area. Unfortunately, the sample population was small. As a result, the generalizations of the findings of the study were limited. Moreover, gender differences were not considered. In the light of these facts, researchers are recommended to consider the five suggestions listed below:

1. This study can be replicated with a larger sample size
2. This study can be replicated by different teachers to decide teacher’s role in the effect of the treatments
3. The effect of PBL and traditional teaching method on students’ performance skills can be determined.
4. The current study can be expanded to a semester long project
5. Gender differences can be studied.

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APPENDIX A

INSTRUCTIONAL OBJECTIVES

Cognitive Domain

- Uses Pythagoras rule to calculate sides of right triangle
- Constructs special right triangles with respect to angles
- Uses characteristics of isosceles triangle
- Uses characteristics of equilateral triangle
- Calculates area of triangle by means of formula
- Uses area formulas of hexagon
- Calculates perimeters of polygons
- Uses area formulas of parallelogram
- Uses area formulas of square
- Uses area formulas of square
- Calculates area of trapezoid by means of formula
- Calculates area of polygons by means of triangular regions
- Calculates area of circle by means of formulas

Psychomotor Domain (Experimental Group)

- Uses and ruler and setsquare in order to draw polygons.
- Uses pair of compasses and protractor in order to draw circular regions.

Affective Domain (Experimental group)

-Preparation with group members before class

- obey timetable for duties
- discuss the content with group members.

Attention to activities in group

- listen to other group members
- ask questions to other group members
- select a resource to get information
- participates in group activities
- respond to group members' questions
- reveal his/her findings to group members

APPENDIX B

GEOMETRİ BAŞARI TESTİ

1. Bölüm: Kişisel Bilgiler

1. Adınız Soyadınız: …….……………………………..

2. Sınıfınız: …………

3. Cinsiyetiniz: …………

4. Yaşınız: ………………

5. Geçen Döneme Ait Matematik Notunuz: …………

6. Annenizin Eğitim Durumu:

a)İlkokul b)Ortaokul c)Lise d)Üniversite e)Y.Lisans d) Doktora

7. Babanızın Eğitim Durumu:

a)İlkokul b)Ortaokul c)Lise d)Üniversite e)Y.Lisans d) Doktora

8. Anneniz Çalışıyor mu? A)Evet b)Hayır

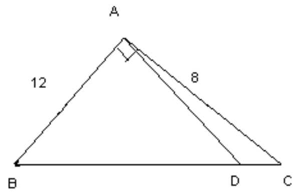
9. Babanız Çalışıyor mu? A)Evet b)Hayır

10. Evinizde bulunan ders kitapları dışındaki kitapların sayısı:

a)0-20 b)21-50 c) 51-100 d)101-200 e)200’den fazla

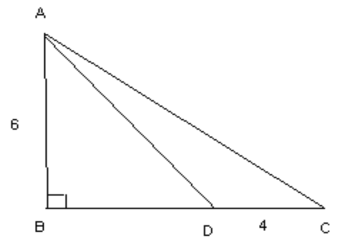
2. Bölüm : Başarılar

1.ABC üçgen [BA] ⊥ [AC] , |BC| =4. |DC| , |AC|=8, |AB|= 12 olduğuna göre Alan (ADB) kaç birim karedir?



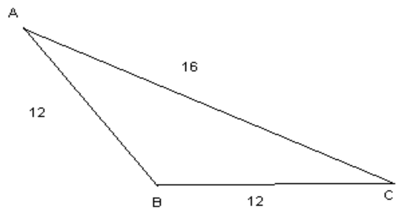
A)18 B)24 C)32 D)36 E)42

2. ABC üçgen, [AB] ⊥ [BC] , |AB|=6, |DC|= 4 olduğuna göre ADC üçgeninin alanı kaç birim karedir?



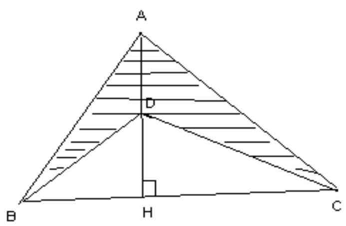
A)6 B)8 C)12 D)18 E)24

3. ABC üçgen |AB|=|BC|= 12, |AC|=16 olduğuna göre Alan (ABC) kaç birim karedir?



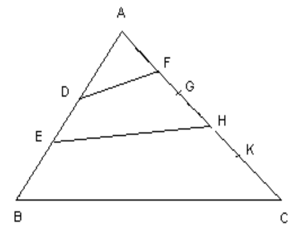
A)16√5 B) 20√5 C) 24√5 D) 32√5 E) 36√5

4. ABC üçgen [AH] ⊥ [BC], |AD|= 3, |BC|=6 olduğuna göre taralı bölgenin alanı kaç birim karedir?



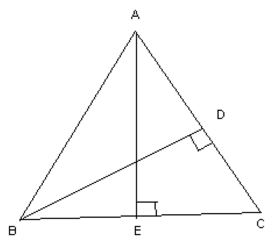
A)9 B) 8 C) 6 D) 3 E) 2

5. ABC üçgeninde [AB] kenarı D ve E noktaları ile 3, [AC] kenarı F,G,H,K noktaları ile 5 eşit parçaya bölünmüştür. Buna göre Alan (DFHE)/Alan (ABC) oranı kaçtır?



A)4/15 B) 1/3 C) 2/5 D) 7/15 E) 8/15

6. ABC üçgen, [BD] ⊥ [AC], [BC] ⊥ [AE] , |AC|= 8, |BC|=12, |AE|= 6 olduğuna göre |BD| kenarı kaç birimdir?

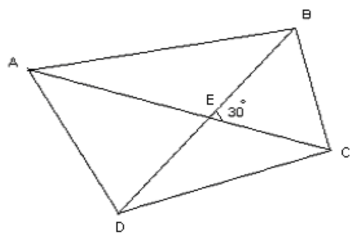


A)3 B) 4 C) 5 D) 6 E) 9

7) Bir kenarı 4 cm olan düzgün bir altıgenin alanı kaç birim karedir?

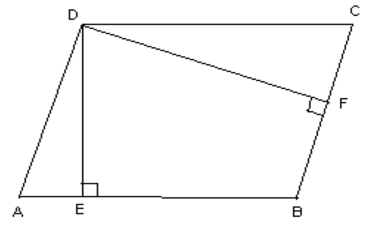
A)24 B) 24√3 C) 36 D) 36√3 E) 30√3

8. ABCD dışbükey bir dörtgen ve |AC|= 8, |BD|=10 ve s(BEC)=30 olduğuna göre Alan(ABCD)=?



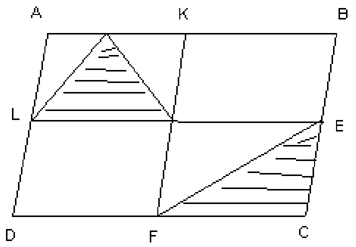
A)10 B) 20 C) 24 D) 40 E) 80

9. Şekildeki ABCD paralelkenarında [DE] ⊥ [AB], [BC] ⊥ [DF] , |AB|= 12, |DE|=4 ve |DF|= 6 olduğuna göre çevre(ABCD) kaç br'dir?



A)20 B)30 C) 24 D) 40 E)50

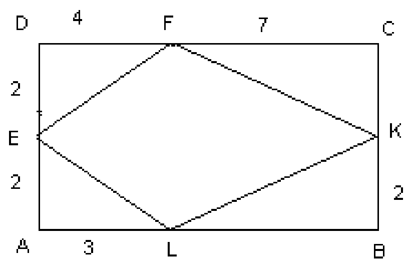
10. Aşağıdaki şekilde verilen ABCD paralelkenarında F,E,K,L bulundukları kenarlarda orta noktalar, [LE] ve [KF] doğrusal olduğuna göre taralı alanlar toplamının paralelkenarın alanına oranı kaçtır?



A)1/12 B)1/8 C) 1/4 D) 3/8 E) 5/8

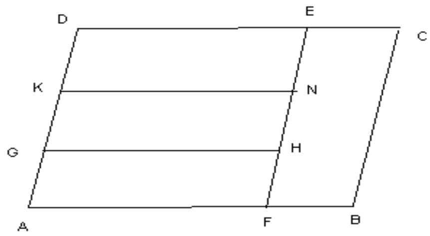
11. ABCD dikdörtgen,

|AE|= |DE|=|KB|=2, |DF|=4, |FC|= 7 ve |AL|=3 ise alan(EFKL) kaç br karedir?



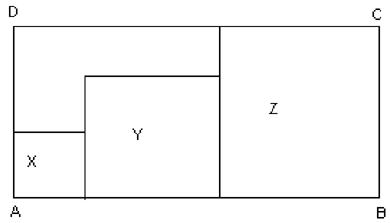
A)20 B)22 C)23 D) 25 E) 28

12. AFHG, GHNK, KNED, EFBC eş paralelkenarlardır çevre(ABCD)=42 cm olduğuna göre |NH|=?



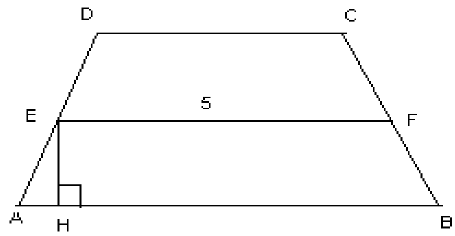
A)1 B)2 C)3 D) 4 E)5

13. ABCD dikdörtgen X,Y,Z ile gösterilen karelerin alanları sırayla 1, 4, 25 ile orantılıdır. |AB|=12 ise y kare bölgesinin alanı nedir?



A)9 B)8 C)7,5 D) 6 E) 4

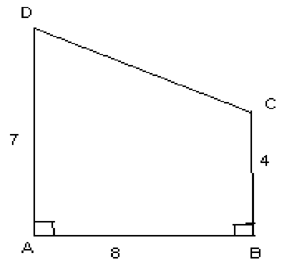
14. ABCD yamuğunda, [EF] orta tabandır. [EH] ⊥ [AB], |EH|=3, |EF|=5 br olduğuna göre Alan(ABCD) kaç br karedir?



A)15 B)20 C)24 D) 30 E) 36

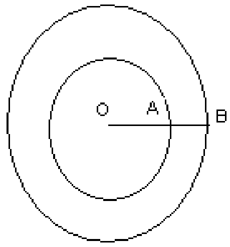
15. ABCD yamuğunda , [AB] ⊥ [CB], [DA] ⊥ [BA] , |AB|=8, |BC|=4, |AD|=7 ise alan (ABCD)=?

A)28 B)35 C)44 D)48 E) 50



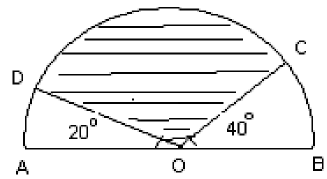
16. O dairelerin merkezi, |OA|=|AB| olduğuna göre büyük dairenin alanının küçük dairenin alanına oranı kaçtır?

A)4 B)2 C)3/2 D)5/3 E) 1

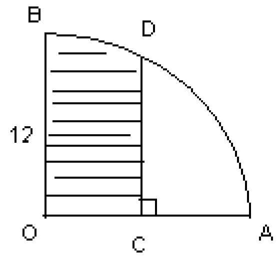


17. AB çaplı O merkezli yarım çemberde m(AOD)=20, m(BOC)=40, |AB|=2√3 br olduğuna göre taralı bölgenin alanı kaç br karedir?

A)π/2 B) π C) 3π/2 D) 4π /3 E) 2π



18. O merkezli çeyrek daire diliminde [OA] ⊥ [DC], |OC|=|CA| , |OB|=12br olduğuna göre taralı bölgenin alanı kaç birim karedir?



A) 18√3+12 π B) 18√3+15π C) 15√3+12π D) 15√3+18π E) 18√3+24 π

APPENDIX C

TABLE OF SPECIFICATION FOR GEOMETRY ACHIEVEMENT TEST

Subject	Comprehension	Application
Triangle	2, 4,6	1, 3, 5
Hexagon	7	
Quadrilateral		8
Parallelogram	9, 10, 12	
Rectangle	11	
Square		13
Trapezoid	15	14
Circle	16, 17	18

APPENDIX D

A İLÇESİ GEOMETRİ PARKI PROJESİ

Amaç: A ilçesi turizmine katkı yapmak amacı ile içerisinde bulunan bütün nesnelerin (ağaç, çiçek, çocuk parkı, kafeterya, lunapark, havuz, yapay nehir vb.) geometrik şekillerden oluştuğu bir geometri parkı çizimi hazırlamak ve bu şekillerin kapladıkları alanları hesaplayabilmek

Görev:

1. Mimar, Peyzaj Mimar, Mühendis, Turizmci vb. gibi kişilerle gerekli görüşmeleri yaparak düşünülen parkın belli bir ölçeğe göre kuş bakışı çizimini yapmak
2. Hazırlanan çizimin sınıf içerisinde sunumunu yapmak
3. Park içindeki farklı geometrik nesnelerin alanlarını hesaplamak için kullanılacak formül ve teknikleri belirlemek
4. Geometrik nesnelerin formüllerini sınıf içinde diğer gruplarla tartışmak
5. Park içindeki nesnelerin alanlarını hesaplamak

Parkta kullanılacak tanımlı geometrik şekiller: Üçgen: Eşkenar, İkizkenar, Çeşitkenar, Dikdörtgen,

Kare,

Paralelkenar,

Yamuk: Düz (Özelliksiz) , İkizkenar, Dik

Düzgün Altıgen,

Dış Bükey Çokgen

Daire: Daire, Daire dilimi, Daire kesiti

APPENDIX E

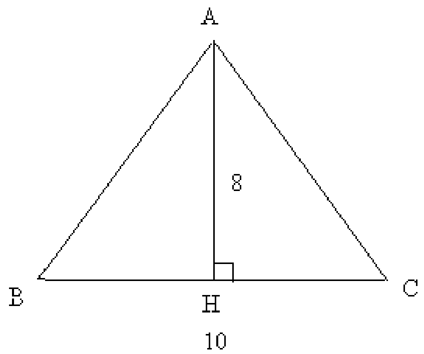
KONTROL GRUBU ÖRNEK DERS PLÂNI

Ders Adı : Matematik (Geometri)
Sınıfı : 9-A / kontrol grubu
Konu : Üçgenin alanı
Hedef : Üçgensel bölgelerin alanının hesaplanabilmesi
Gerekli Ön Bilgi : Pisagor kuralı, eşkenar ve ikizkenar üçgenin temel Özellikleri, Açılarına göre özel dik üçgenler.
Öğretim Metodu : Geleneksel öğretim metotları, düz anlatım, tartışma
Ders Araç ve Gereçleri : 10. ve 11. sınıf geometri kitabı
Süre : 4 Ders saati

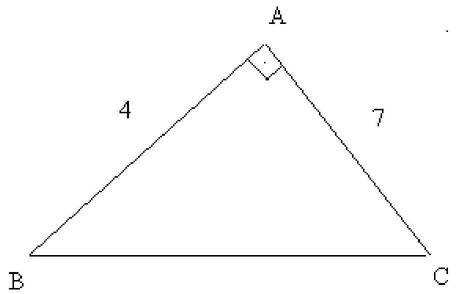
Dersin İşlenişi:

Konuya öğrencilere üçgenin alan formülü sorularak başlandı. Öğrenciler Alan= (taban x yükseklik)/2 yanıtını verdiler. Ardından konu ile ilgili iki soru soruldu.

Soru 1.

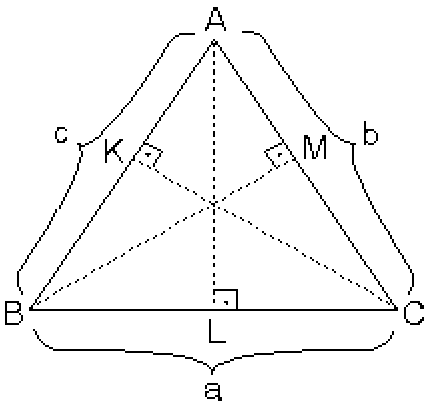


Soru 2.



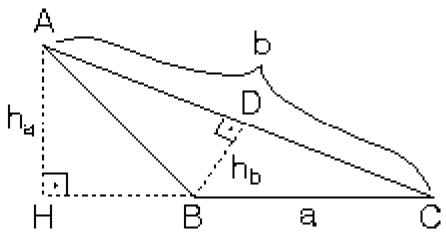
İlk örnekte bütün öğrenciler yanıtı bulurken ikinci örnekte birkaç öğrenci cevabı bulabildi. Her iki örnek için bir öğrenci dersi tahtada çözdü. Derse genel bir giriş yapıldıktan sonra; üçgenin alan formülünün neden (taban x yükseklik) /2 olduğu tartışıldı. Öğrencilerin formülü daha iyi anlayabilmesi için kare, dikdörtgen ve paralelkenar şekilleri tahtaya çizildi ve yorum yapılması istendi. Tartışma 15dk kadar sürdü.

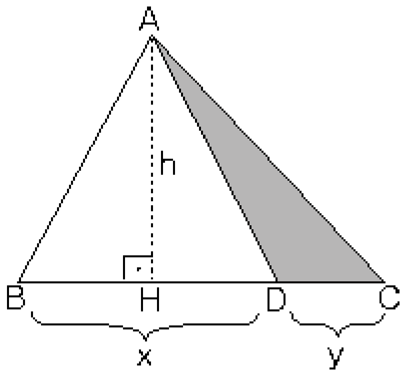
Daha sonra aşağıdaki şekil tahtaya çizildi ve alan formülü verildi.

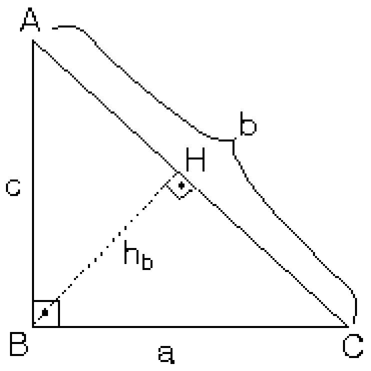


$$A(\widehat{ABC}) = \frac{a \cdot h_a}{2} = \frac{b \cdot h_b}{2} = \frac{c \cdot h_c}{2}$$

Ayrıca değişik üçgen şekillerinde alanın nasıl bulunabileceği ile ilgili aşağıdaki şekiller tahtaya çizildi ve alan formülleri tekrar edildi.



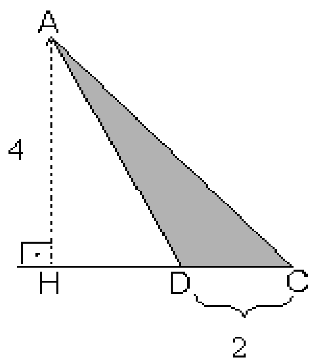




$$A(\widehat{ABC}) = \frac{a \, . \, c}{2} = \frac{b \, . \, h_c}{2} \Rightarrow a \, . \, c = b \, . \, h_b$$

Ardından alıştırma yapılmaya başlandı.

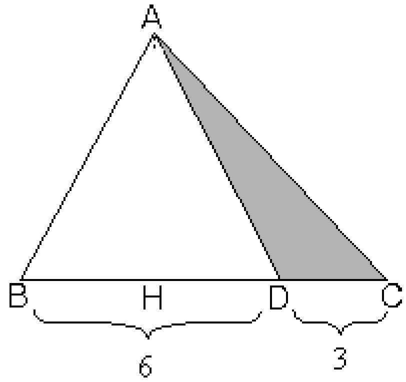
Soru 3.



Şekilde verilen ADC üçgeninin alanını bulunuz.

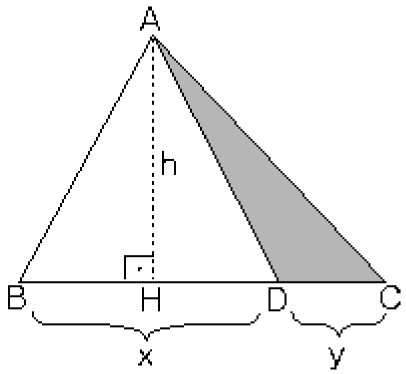
Sorunun çözümü öğrenciler tarafından yapıldı. Alan formülü= (taban x Yükseklik)/2 =(4 x 2)/2=4br2

Soru 4. (Bu soruda öğrencinin yükseklikleri aynı ama tabanları farklı olan üçgenlerin alanları arasındaki ilişkiyi anlaması amaçlandı) 1



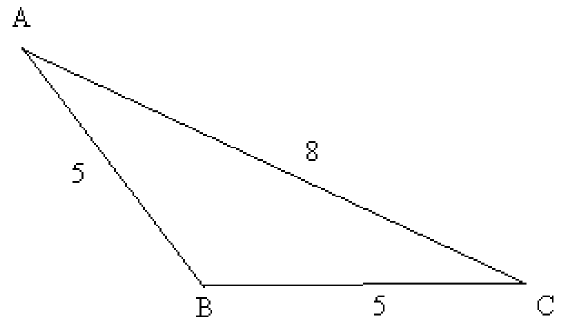
Şekilde ADC üçgeninin alanın 20br2 olduğuna göre DAB ve ABC üçgenlerinin alanlarını bulunuz.

Bu soruda öğrenciler bir süre durakladı ve yüksekliğin verilmesi gerektiğini söyleyenler oldu. 1-2 dakika sonunda kendilerinin bir yükseklik çizerek sorunun çözümünü bulabileceklerini gördüler. Yüksekliği bulmaya çalışırken yüksekliğin tamsayı çıkmadığını sorunun yanlış olabileceğini söyleyen öğrenciler oldu. Sorunun çözümü 3-4 dakika sürdü. Daha sonra öğrencilere yükseklik bulunmadan diğer alanların bulunup bulunamayacağı soruldu tartışmada öğrenciler fazla yorum yapamayınca öğretmen ipuçları verdi. 10 dakika içerisinde aşağıdaki sonuca ulaşıldı.



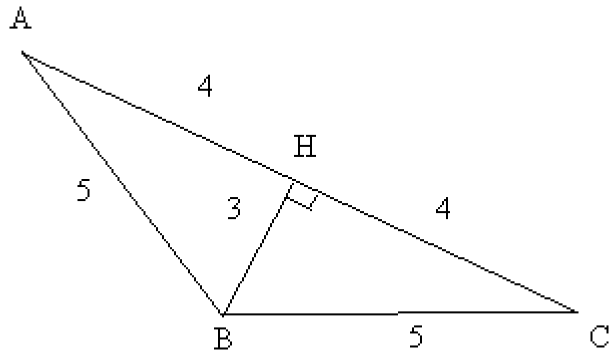
$$\frac{A(\widehat{ABD})}{A(\widehat{ADC})} = \frac{x}{y}$$

Soru 5. (Daha sonra ikizkenar üçgenin alanı ile ilgili bir soru soruldu)



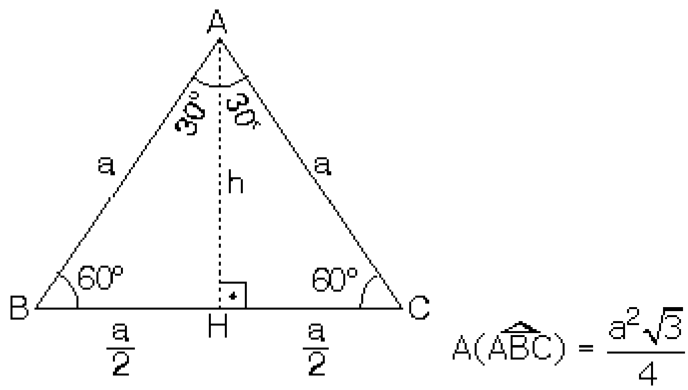
Boyutları şekil üzerinde verilen ABC üçgeninin alanını bulunuz.

Öğrenciler yükseklik göremedikleri için soruya cevap veremediler. Öğretmen İkizkenar üçgenin özelliklerini kullanmalarını tavsiye etti. Sorunun çözümü öğrenciler tarafından yapıldı.



Çözümde; B köşesinden [AC] tabanına bir dik indirildi. Pisagor kuralı uygulanarak [BH] yüksekliğinin uzunluğu bulundu ve alan formülü uygulandı.

Eşkenar üçgenin alanı ile ilgili alan formülü öğrencilere anlatıldı.

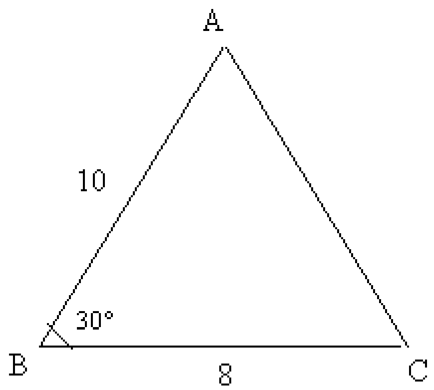


Ancak öğrencilerden formülü ezberlememeleri sadece daha önce öğrendikleri eşkenar üçgen özelliklerini kullanarak alanı bulabilecekleri hatırlatıldı.

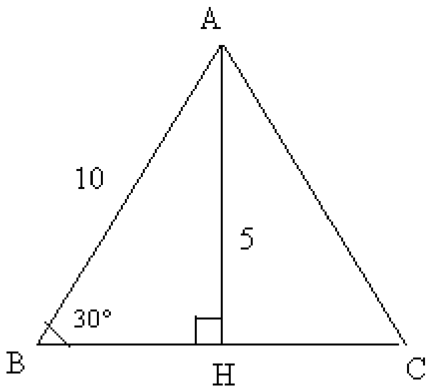
Soru 6. Bir kenarı 6br olan eşkenar üçgenin alanını bulunuz.

Bu sorusunun cevabı alınırken öğrencilerden kısa formülü kullanmamaları bunun yerine temsili bir şekil çizerek eşkenar üçgenin özellikleri ve üçgenin alan formülü kullanılarak sonuca varmaları istendi.

Soru 7.



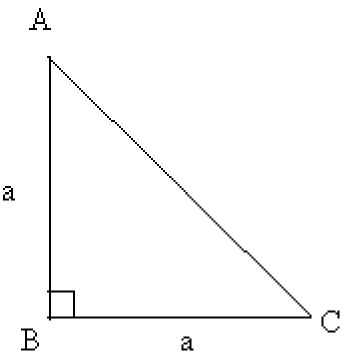
Şekildeki ABC üçgende |AB|= 10br. , |BC|= 8br. ve B açısının ölçüsü 30° olduğuna göre ABC üçgeninin alanını bulunuz.



Soru 30°-60°-90° üçgeni oluşturularak yükseklik bulundu ve alan formülü uygulandı.

Soru 8. İkizkenar bir dik üçgenin alanını nasıl bulabileceğimizi açıklayınız?

Bu soruda öğrencilerin konu üzerinde yorumları öğrenilmeye çalışıldı. Öğrencilerin büyük bir kısmı soruyu aşağıdaki şekli çizerek formülleştirdi.



Alan = (a x a)/2 = a2/2

Ölçme ve değerlendirme: Appendix H deki sorular ödev olarak verildi. Çözümlerin kontrol edilerek konunun anlaşılıp anlaşılmadığının belirleneceği ve soruların sınıfta öğrenciler tarafından çözüleceği bildirildi.

APPENDIX F

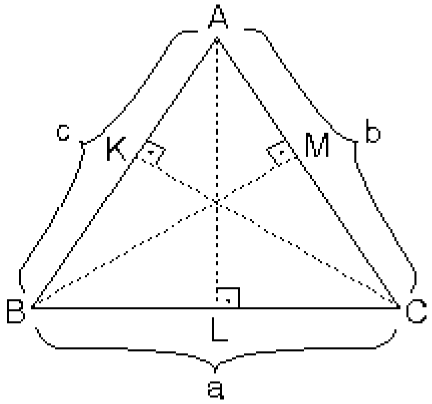
DENEY GRUBU ÖRNEK DERS PLÂNI

Ders Adı : Matematik (Geometri)
Sınıfı : 9-B / Deney grubu
Konu : Üçgenin alanı
Hedef : Üçgensel bölgelerin alanının hesaplanabilmesi
Gerekli Ön Bilgi : Pisagor kuralı, eşkenar ve ikizkenar üçgenin temel Özellikleri, Açılarına göre özel dik üçgenler.
Öğretim Metodu : Problem tabanlı öğrenim metodu, tartışma
Ders Araç ve Gereçleri : 10. ve 11. sınıf geometri kitabı
Süre : 3 Ders saati
Sunum Yapan Grup : Su Bazlı Az Nazlı

Dersin İşlenişi (Derste anlatılacak konuları öğretmen ve grup elemanları birlikte hazırlamışlardır) :

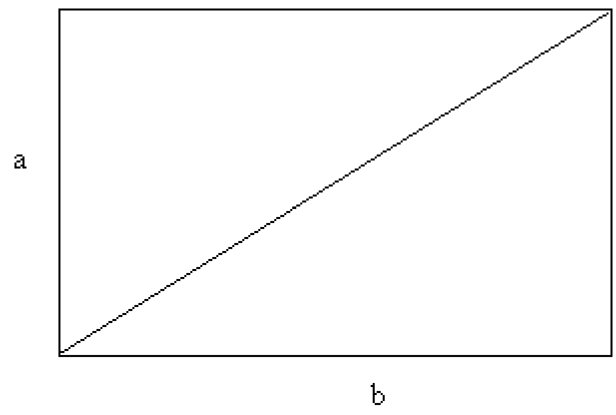
Anlatan: Servet (Rumuz)

Hakan konuya üçgenin alan formülünü vererek başladı. Öğrenciler geometri parkında konuyu bireysel ve grup olarak çalıştıkları için formülü biliyorlardı.



$$A(\widehat{ABC}) = \frac{a \cdot h_a}{2} = \frac{b \cdot h_b}{2} = \frac{c \cdot h_c}{2}$$

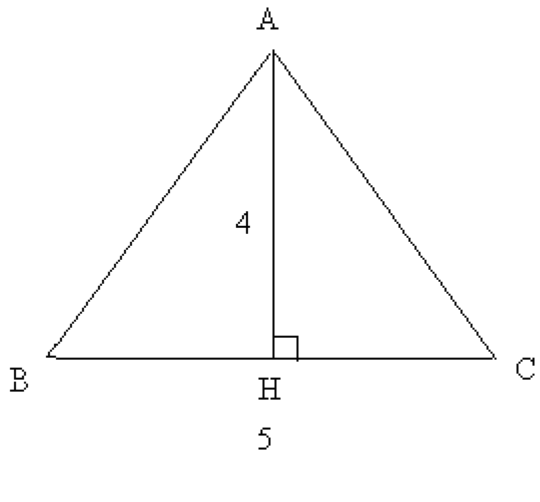
Ancak konuya başlanırken öğrencilerden bir tanesi üçgenin alan formülünün neden (taban x yükseklik)/2 olduğunu sordu. Ve sınıf içinde bir tartışma başladı. Tartışma 5 dakika kadar sürdü ve anlatan gruptan Arda aşağıdaki şekille arkadaşlarını ikna etti.



Açıklamasında 'dikdörtgenin alanı eni ile boyunun çarpımıdır, bunu ikiye bölersek üçgenin alanını elde ederiz' dedi. Öğrenciler ikna oldu.

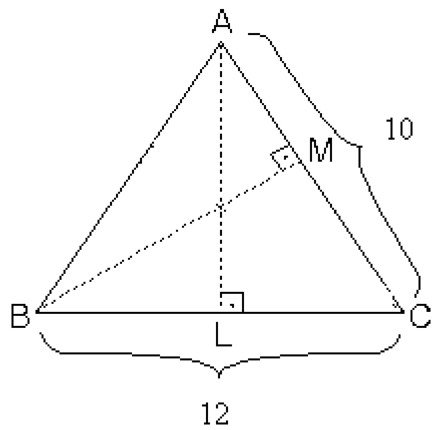
Daha sonra Hakan konu ile ilgili örnekler vermeye başladı.

Soru 1.



Hakan sorunun çözümü için sınıftan gönüllü bir öğrenci seçti ve alan formülü uygulanarak soru çözüldü.

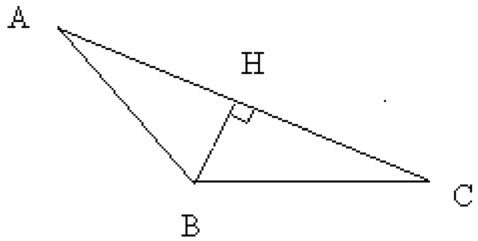
Soru 2.



Şekildeki üçgende |AC|= 10 br, |BC|= 12 ve |BM|=6 birim olarak verilmiştir. Buna göre [AL] kenarının uzunluğunu bulunuz.

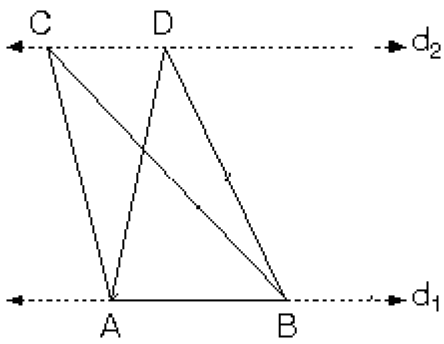
Bu soruda öğrenciler [AL] kenarının uzunluğunu bulmak için Pisagor kuralı uygulanması gerektiğini belittiler. Yapamayınca sesli düşünmeye başladılar. Sorunun cevabını Hakan verdi.

Soru 3.



|AC|= 7br, |BH|= 3br. ise ABC üçgeninin alanını bulunuz. Tüm gruplar soruyu çözdü ve gönüllü bir öğrenci soruyu tahtada çözdü.

Soru 4.



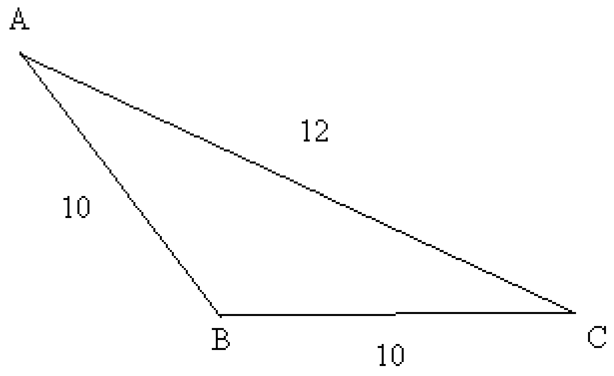
Şekilde d1//d2 olduğuna göre ABC üçgeninin alanı ile ADB üçgeninin alanı arasındaki bağlantıyı belirtiniz.

Öğrenciler hemen alanların birbirlerine eşit olduğunu belirttiler. Ancak eşitliğin nedeni sorulduğunda cevap vermekte zorlandılar ve tartışma birkaç dakika sürdü. Daha sonra Hakan'ın yardımıyla sonuca ulaştılar; yükseklikleri ve dolayısıyla alanları aynıdır.

Anlatan: Ayhan (Rumuz)

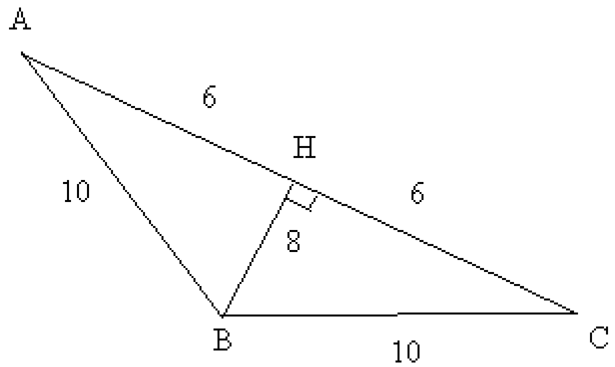
İkizkenar üçgenin alanının nasıl bulunabileceği ile ilgili örnek vererek derse başladı.

Soru 5.



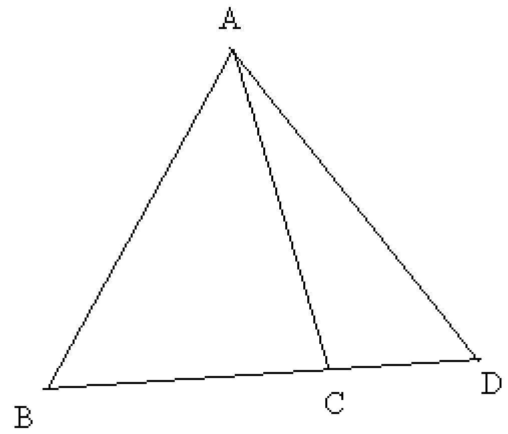
Boyutları şekil üzerinde verilen ABC üçgeninin alanını bulunuz.

Öğrencilerden herhangi iki kenarı çarpıp ikiye bölerek sonuç söyleyenler oldu. Örneğin; 10 x 12= 120, 120/2=60. Ayhan öğrencilere ‘bize bir yükseklik gerekli sizce ikizkenar üçgende yükseklik nereden çizilmeli? ‘ sorusunu sordu. Soruyu iki grup çözdü. Ve bir öğrenci soruyu tahtada yanıtladı.



Çözümde; B köşesinden [AC] tabanına bir dik indirildi. Pisagor kuralı uygulanarak [BH] yüksekliğinin uzunluğu bulundu ve alan formülü uygulandı. Ve Taban= 12 br, Yükseklik= 8br oldu.

Soru 6.

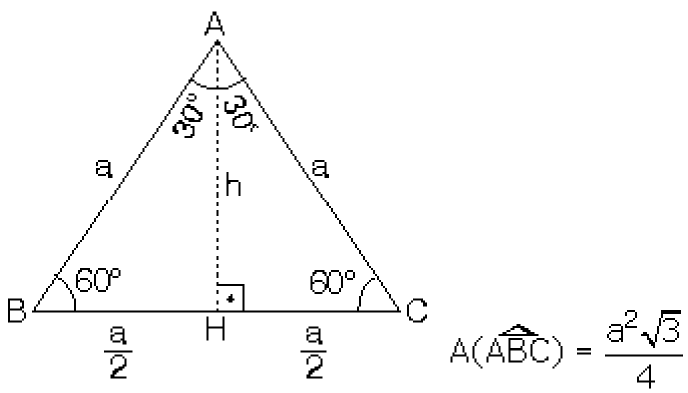


Şekildeki üçgende |BD|=3 x |CD| olduğuna göre ACD üçgeninin alanının ABD üçgeninin alanına oranını bulunuz.

Diğer gruplara düşünmek için biraz süre verildi. Gruplardan bazıları soruyu çözmek için daha fazla veriye ihtiyaçları olduğunu söyledi. Ancak iki grup sorunun çözümünü sözel olarak anlattılar; iki üçgenin alanları oranı tabanları oranı ile aynıdır.

Anlatan: Doğa

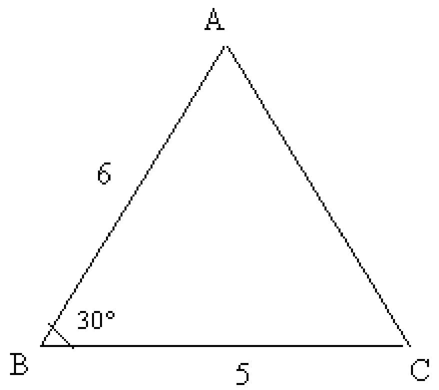
Doğa sunumuna eşkenar üçgenlerin alanı konusu ile başladı. Ve doğrudan konuyu anlattı.



Soru 7. Bir kenar uzunluğu 4br olan eşkenar üçgenin alanını bulunuz.

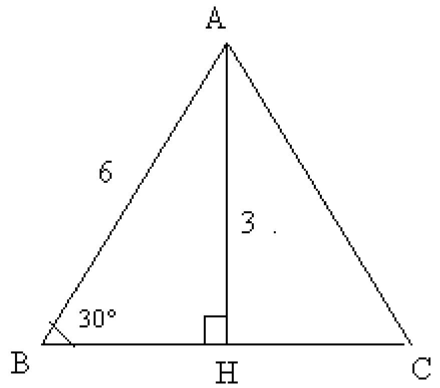
Öğrenciler formül yardımı ile sonucu buldular. Ancak ders öğretmeni sonucun üçgenin genel alan formülü ile yapılmasını istedi. Ancak yine yukarıdaki şekil yardımı ile bütün gruplar soruyu kolayca yanıtladı.

Soru 8.



Şekildeki ABC üçgeninin alanını bulunuz.

Sorunun çözümünde gruplar zorlandı. Çünkü çözüm için grupların B açısından yaralanarak bir yükseklik oluşturmaları ve yüksekliği bulmaları gerekiyordu.



Yani '30°-60°-90° üçgeni oluşturarak yükseklik, |AH|=3br bulunmalı ve alan formülü uygulanmalı idi. Doğa ipuçları vererek grupları çözüme yönlendirdi.

Ödev sorularının çözümünü Arda yapacak.

Ölçme ve değerlendirme: Appendix H deki sorular ödev olarak verildi. Çözümlerin kontrol edilerek konunun anlaşılıp anlaşılmadığının belirleneceği ve soruların sınıfta öğrenciler tarafından çözüleceği bildirildi.

APPENDIX G

GRUP İŞ PLANI

Grup Adı: Su Bazlı Az Nazlı

Grup Elemanları: Arda, Servet, Doğa, Ayhan

Görev Dağılımı:

Arda : internetten park planı araştırma
Servet: plandaki geometrik şekillerin alanlarını hesaplama
Doğa : plandaki geometrik şekillerin alanlarını hesaplama ve araç-gereç temini
Ayhan: park planını çizme

Parkta Düşünülen Binalar ve Etkinlikler:

Termal hamam, kafe, futbol sahası, havuz, kaydırak dönme dolap salıncak, çimenlik alan, koşu pisti, büfe, gondol, asansör

Çalışma Takvimi:

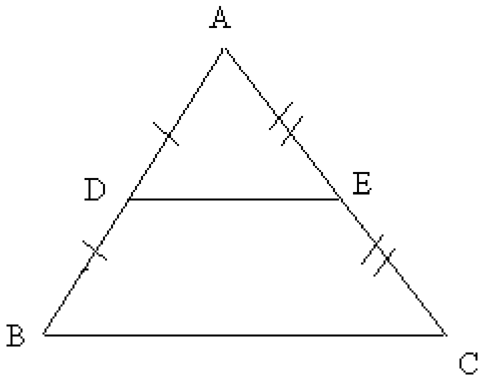
19 Eylül: Parktaki şekillere karar verme (Toplantı)
20 Eylül: Park planlarının hazırlanması ve geometrik şekillerinin alanlarının tartışılması (Toplantı)
21 Eylül: Parkın Kaba Taslak Çizimi (Toplantı)
22–23 Eylül: Alan çalışmaları (Bireysel çalışma)
24 Eylül: Çalışmaların gözden geçirilmesi (Toplantı)
25 Eylül: Teslim

Not: Kullanılan isimler rumuzdur.

APPENDIX H

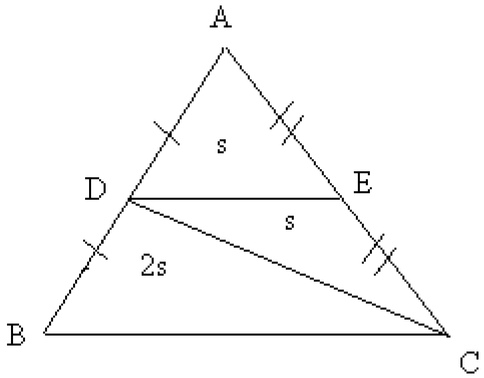
ÜÇGEN EV ÖDEVİ

1.



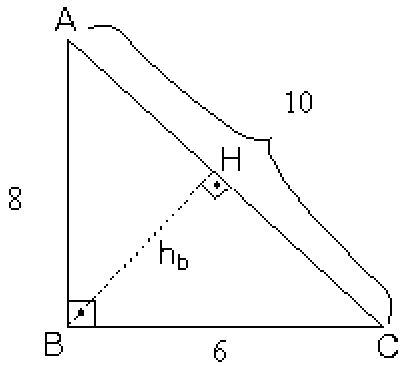
ABC üçgeninde D ve E noktaları bulundukları kenarların orta noktalarıdır. Buna gore A(ABC)/A(ADE)=?

Çözüm:



A(ABC)=4s birim, A(ADE)=s birim. 4s/s=4

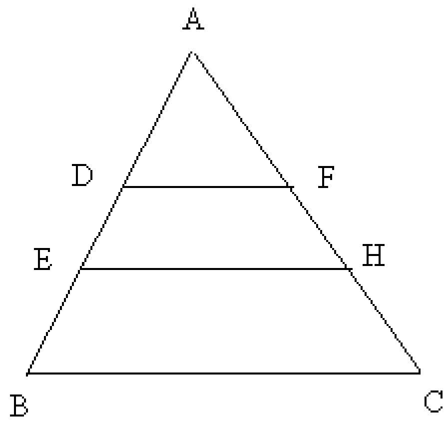
2.



|AB|= 8br, |BC|=6br, |AC|= 10br olduğuna gore |BH|=?

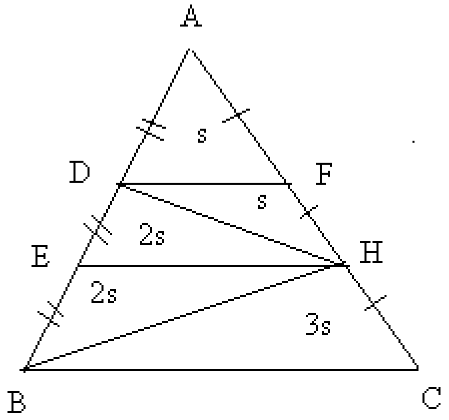
Çözüm: (8 x 6)/2= (|BH| x 10)/2. |BH|=24/5

3.



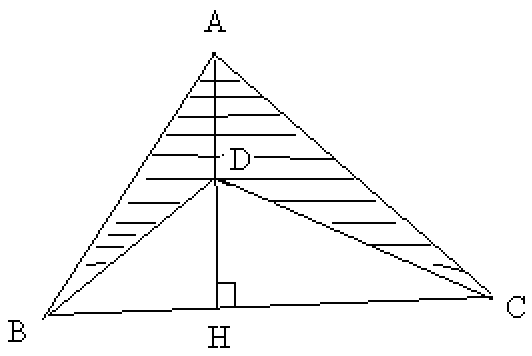
ABC üçgeninin [AB] ve [AC] kenarları şekildeki gibi üç eş parçaya ayrılmıştır. A(DEFH)/A(ABC) nedir?

Çözüm:



(3s)/(9s)=1/3

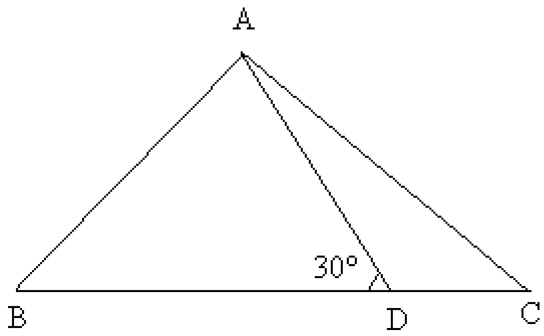
4.



ABC üçgen, |AD|= 5br, |BC|=6br olduğuna göre taralı bölgenin alanı kaç birim karedir?

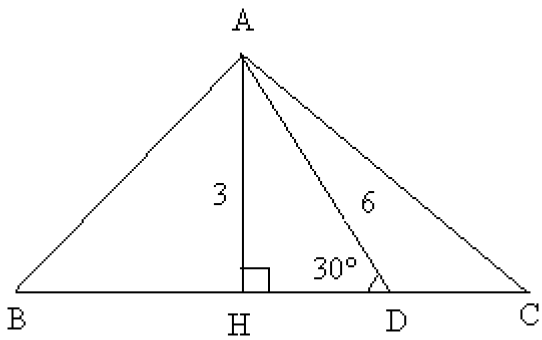
Çözüm: [BH]= a olsun [HC]=6-a olur. A(ADB)=(a x 5)/2 ve A(ADC)= ((6-a) x 5)/2 toplam taralı alan (6 x 5)/2=15br2

5.



ABC üçgeninde |BC|=12br ve |AD|=6br olduğuna göre ABC üçgeninin alanı kaç birim karedir?

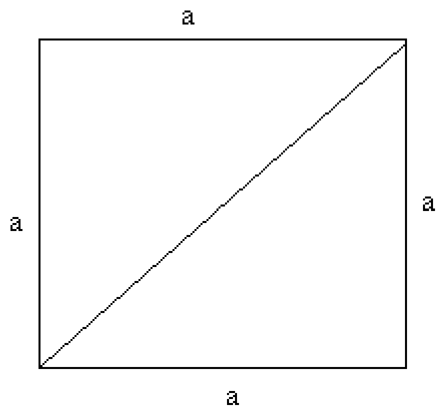
Çözüm:



A köşesinden bir yükseklik indirerek, 30°, 60°, 90° üçgeni yardımı ile yüksekliği 3br buluruz. Alan= (3 x 12)/2=18

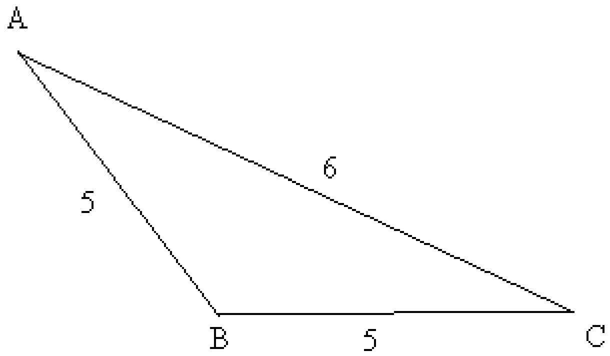
6. ikizkenar üçgenler kullanarak kare elde edilebilir mi? İkizkenar üçgenlerin alan formülleri kullanılarak karenin alan formülü elde edilebilir mi?

Çözüm:



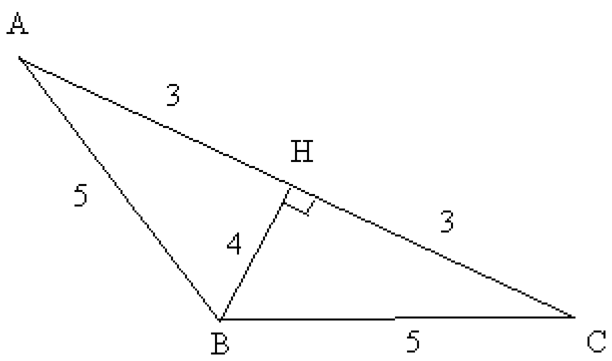
Kareyi oluşturan her bir ikizkenar üçgenin alanı $a^2/2$'dir. Toplam alan ise a^2'dir.

7.



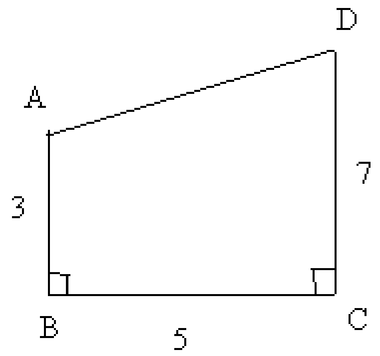
ABC üçgeninin alanı kaç birim karedir?

Çözüm:



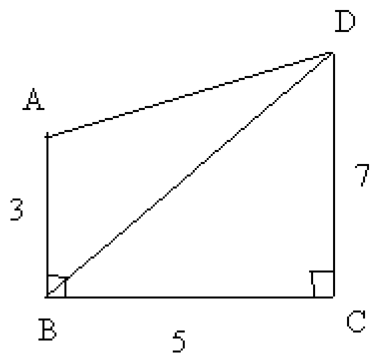
B köşesinden [AC] tabanına bir dik indirildi. Pisagor kuralı uygulanarak [BH] yüksekliği 4br bulunur. Alan= (6 x 4)/2=12br^2

8.



Yukarıdaki şeklin alanını üçgenlere bölerek bulunuz.

Çözüm:



Şekilde iki üçgen elde edildi. Alanlar toplamı: ((7 x 5)/2)+((3 x 5)/2)=25br2.