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# THE DEVELOPMENT PROCESS OF CONTEXTUAL BASED INSTRUCTIONAL GEOGEBRA WORKSHEETS FOR TURKISH HIGH SCHOOL MATHEMATICS TEACHERS

A MASTER'S THESIS

BY

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THE PROGRAM OF CURRICULUM AND INSTRUCTION
BILKENT UNIVERSITY
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VOLUME I

*I dedicate this thesis study to*

*my dearest FAMILY*

*with respect, gratitude and love ...*

*Respect comes first because according to my mother respect is as important as love*

*and sometimes it is more important.*

# THE DEVELOPMENT PROCESS OF CONTEXTUAL BASED INSTRUCTIONAL GEOGEBRA WORKSHEETS FOR TURKISH HIGH SCHOOL MATHEMATICS TEACHERS

The Graduate School of Education

of

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by

Hamide Akkoca

In Partial Fulfilment of the Requirements for the Degree of Master of Arts

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GRADUATE SCHOOL OF EDUCATION

THE DEVELOPMENT PROCESS OF CONTEXTUAL BASED INSTRUCTIONAL GEOGEBRA WORKSHEETS FOR TURKISH HIGH SCHOOL MATHEMATICS TEACHERS

HAMİDE AKKOCA

May, 2014

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Arts in Curriculum and Instruction.

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## ABSTRACT

THE DEVELOPMENT PROCESS OF CONTEXTUAL BASED INSTRUCTIONAL GEOGEBRA WORKSHEETS FOR TURKISH HIGH SCHOOL MATHEMATICS TEACHERS

Hamide Akkoca

M.A., Program of Curriculum and Instruction
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May 2014

The purpose of this study was to develop contextual based geogebra worksheets to help Turkish high school mathematics teachers learn how to use GeoGebra appropriately and efficiently in teaching and learning of geometry. The Ministry of National Education *[Milli Eğitim Bakanlığı]* (MEB) has recently published a new mathematics curriculum to be taught in all high schools in Turkey from September 2013. The new curriculum contains geometry lesson objectives which require mathematics teachers to prepare a lesson combined with GeoGebra. However, Turkish high school mathematics teachers are not provided with anylessons or provided with limited lessons concerning GeoGebra by Council of Higher Education *[Yükseköğretim Kurulu]* (YÖK). Within this context, the results of the study are of great importance that Turkish high school mathematics teachers do not have only necessary skills to use GeoGebra but also how to use GeoGebra to achieve geometry lesson objectives written in the new curriculum.

The participants of the study consisted of 7 first year pre service mathematics teachers who were enrolled in Graduate School of Education at Bilkent University in 2013. In this study to collect data, a survey with 7 diferent parts which have 63 questions in total on a 5 level Likert and alsothrough verbal was utilized and written feedbacks which were provided by first year pre service mathenatics teachers were collected.Simple descriptive statistics was conducted to analyze the data collected thorough a survey and written and verbal feedbacks were categorized.

The results and findings of the study indicated that intrinsic motivation and general computer literacy knowledge level are two important factors that affect the learning of GeoGebra. Intrinsically motivated learners and high level users on general computer literacy knowledge learn faster and more meaningfully. Another important conclusion formed from this studyis that learning will happen more effectively when contextual based worksheets are created by difficulty levels than the contextual based worksheets are developed considering holistic approach of GeoGebra.

Key words: *GeoGebra, dynamic mathematics software, general computer literacy knowledge, contextual-based learning, pre-service mathematics teachers.*

# ÖZET

TÜRK LİSE MATEMATİK ÖĞRETMENLERİ İÇİN OLUŞTURULAN BAĞLAMSAL İÇERİKLİ GEOGEBRA ÇALIŞMA KAĞITLARININ GELİŞTİRİLME SÜRECİ

Hamide Akkoca

Yüksek Lisans, Eğitim Programları ve Öğretim

Tez Yöneticisi: Doç. Dr. Erdat Çataloğlu

Mayıs 2014

Bu çalışmanın amacı Türk lise matematik öğretmenlerine geometri dersinin öğreniminde ve öğretiminde GeoGebra' yı etkili ve uygun bir şekilde kullanmalarına yardım etmek için bağlamsal içerikli GeoGebra çalışma kâğıtları geliştirmektir. Milli Eğitim Bakanlığı 2013 yılında Eylül ayı içerisinde Türkiye' deki tüm liselerde kullanılmak üzere yeni bir matematik müfredatı yayınlamıştır. Yeni matematik müfredatında matematik öğretmenlerinin GeoGebra' yı kullanarak dersler hazırlamalarını içeren geometri ders kazanımları yer almaktadır. Bununla birlikte, Türk lise matematik öğretmenlerine Yüksek Öğretim Kurulu tarafından GeoGebra ile ilgiliders temin edilmemektedir ya da kısıtlı dersler temin edilmektedir. Bu bağlamda bu çalışmanın sonuçları Türk lise matematik öğretmenlerine sadece GeoGebra' yı kullanmak için gerekli olan becerileri kazandırmakla kalmayıp aynı zamanda yeni müfredatta yazan geometri ders hedeflerine ulaşmaları için GeoGebra' yı nasıl kullanacaklarına yönelik becerileri kazandırması açısından büyük önem taşımaktadır.

Çalışmanın katılımcılarını 2013 yılında Bilkent Üniversitesi Eğitim Fakültesi' ne giriş yapanbirinci sınıf 7matematik öğretmen adayı oluşturmaktadır. Bu çalışmada, veri toplamak için 7 ayrı bölümden oluşan ve toplamda 63 tane soru içeren bir anketten yararlanmıştır ve buna ek olarak birinci sınıf matematik öğretmenleri tarafından verilen yazılı ve sözlü geri bildirimler toplanmıştır. Anket aracılığı ile toplanan veriler basit betimleyici istatistik kullanılarak analiz edilmişyazılı ve sözlü geri bildirimler ise kategorilere ayrılmıştır.

Bu çalışmanın sonuçları ve bulguları göstermektedir ki içsel motivasyon ve bilgisayar okur-yazarlığı bilgisi GeoGebra' nın öğreniminde büyük etkisi olan iki önemli faktördür. İçsel motivasyona ve yüksek seviyede bilgisayar okur-yazarlığı bilgisine sahip olan kullanıcılar daha hızlı ve daha anlamlı bir şekilde öğrenmektedir. Bu çalışmadan çıkarılan diğer bir önemli sonuç ise GeoGebra ders hedeflerine bütüncül bir yaklaşımla hazırlanan bağlamsal içerikli çalışma kâğıtları yerine zorluk seviyeleri temel alınarak hazırlanan bağlamsal içerikli çalışma kâğıtları ile daha etkili bir öğrenme gerçekleşecektir.

Anahtar kelimeler: *GeoGebra, dinamik matematik yazılımı, genel bilgisayar okur-yazarlığı bilgisi, bağlam temelli öğrenme, matematik öğretmen adayları.*

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I am very much indepted to the foundation of everything which is family, my father Hüseyin Akkoca, my mother Elif Akkoca, my brother Hasan Akkoca and my sister Bensu Akkoca for their continuous support to me and to all my decisions as well. My parents believe that education is necessitiy to further the life so they worked hard to provide a foundation for my life and a good future to me. I would like to thank you them for their sacrifices for bringing me up. I also would like to thank my brother and my sister especially for offering me limitless love and tremendous support. I feel lucky to be a part of such an amazing and a unique family in many ways.

I am grateful to everyone who helps me get to where I am today and makes my dreams a reality.

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# CHAPTER 1: INTRODUCTION

## Introduction

Technology has been used as an aiding tool almost in every part of the life since ancient times. The rapid changes in the world and the desire for a better life led to of technological improvements. Living in a world without technology is almost impossible, and the effect of technology in our lives is inevitable.

As an essential part of our lives, education has been a field on which technology has a huge impact. With the developments in technology in the second half of the twentieth century, new potentials were gained, and the rapid transformation of the teaching and learning of mathematics has been a necessity (Lavicza, 2010). Therefore, the integration of technology into education can be considered a need for individuals who grew up with technology.

Over the years, technology integrated lessons have become one of the hot topics with the increment of the need for technology. Several studies and research were carried out. Most of the studies indicate that technology has a positive impact on education.

It is well-known that lessons supported with the appropriate use of technology ensure more effective teaching and learning than lessons taught traditionally. Technology proficient teachers can use their skills to create a more meaningful learning environment. Therefore, technology-orientated education becomes more crucial every day.

Attempts to use technology in education have been gradually increasing in Turkey. The most important step taken on this issue is the high school mathematics curriculum developed by MEB. In this new curriculum, teachers are required to use GeoGebra to facilitate teaching and learning processes.

Although it is a must for mathematics teachers to integrate GeoGebra into their teachings and learning processes, they receive either limited or no training on integration of technology. Therefore, they cannot achieve objectives properly. This study intends to develop contextual-based instructional GeoGebra worksheets for high school mathematics teachers.

## Background

Technology has been an integral part of mathematics education i.e., the teaching and learning of mathematical concepts, since the origin of mathematics (Roschelle, Shechtman, Tatar, Hegedus, Hopkins, Empson, Knudse, & Gallaghe, 2010). For example, clay tablets were once used to demonstrate calculations. Similarly, it is been said that Socrates was drawing figures on the sand, to show the basic elements of geometric figures while teaching his students. Even earlier on, Abacus was known to be used by ancient people to perform arithmetic computations not only for trading purposes but also for educational purposes. (Trouche & Drijvers, 2010). The foregoing examples demonstrate that technology has been used in mathematics education as an aiding tool since the very beginning of mathematics education. So it should not come to a surprise that mathematics teachers and related stakeholders consistently try to incorporate new technologies into mathematics education

Clearly, the advancements in the technology led to a shift from clay tablets, compasses, rulers, books, paper, and pencils to digital calculators and computers.

(Trouche & Drijvers, 2010). Now, the technology used in teaching mathematics has various forms such as dynamic mathematics software, smart boards, virtual manipulatives, graphing calculators, computer algebra system, tablet PC, computers, etc.

In Turkey, formal attempts to integrate digital technology into mathematics education began in 1984. One thousand and one hundred computers in total were bought for the purpose of making computer education available in secondary schools (Odabaşı, 1998). Shortly therafter, the first "Computer Assisted Learning (CAL) Conference in Turkey" was held in 1987. In 1989, application model, software, teacher training, hardware and experimental planning of CAL were discussed in the First Consultative Committee of CAL. The Second Consultative Committee for CAL was held in 1990. During the same time period the number of computers in secondary schools increased from to one thousand and one hundred to five thousand. Similar attempts as mentioned above are still on going. MEB still continues to develop and apply projects to extend the use of technologies in teaching and learning at all levels.

As technology improved, contents of the projects implemented in Turkey were enriched for an enhanced teaching and learning through technology. The Movement to Enhance Opportunities and Improve Technology abbreviated as FATİH *[Fırsatları Artırma ve Teknolojiyi İyileştirme Hareketi]* may be given as an example of such projects. The goal of FATİH project is to improve technology in schools and to ensure equality of educational opportunity. In order to achieve this goal, smart boards are distributed to the schools, and high speed Internet access is made available in every classroom.Furthermore, MEB published a new curriculum in which integration of technology into mathematics education plays a key role. The curriculum underlines benefits of using technology in teaching and learning, and strongly recommends the use of technology as an aiding tool to mathematics teachers. The clear statement of MEB about the use of technology in mathematics education is as follows: "Bilgi ve iletişim teknolojilerinin bilinçli kullanımı, teknolojinin matematik becerilerinin öğrenilmesinin yerini almasını değil; aksine, beceri seviyelerini gözetmeksizin tüm öğrencilere matematiksel düşünceyi ulaşılabilir kılmayı amaçlamaktadır. Örneğin, BİT, sınırlı matematik bilgisi ve sınırlı sembolik ve sayısal işlem yapma becerisine sahip öğrencilere, problem çözme sürecine dâhil olma olanağı vermektedir. Bu bağlamda kullanılacak uygun araçlar, öğrencileri uzun ve birbirini tekrar eden hesaplamalardan kurtarabilir, çoklu ortam ve temsillerin kullanılmasını teşvik edebilir. Farklı teknolojiler, özellikle de farklı yazılımlar modelleme ve problem çözme sürecinin değişik aşamalarını desteklemekte; çoklu temsillere (sayısal, cebirsel, grafik) imkân sağlayarak öğrencilerin matematiksel durumları daha iyi anlamalarına ve farklı düşünme yollarını tecrübe ederek bunların sonuçlarını daha hızlı bir şekilde değerlendirmelerine imkân sağlamaktadır. Diğer bir deyişle, bilgi ve iletişim teknolojilerinin etkili kullanımıyla öğrenciler gerçek/gerçekçi matematik problemleri üzerinde çalışabilir ve uzun işlemlerden kazanacakları zamanı akıl yürütmede ve yaratıcı düşünmede kullanabilirler. Bu çerçevede, öğrencilerin bilgi ve iletişim teknolojilerini yerinde kullanmayı öğrenmesine önem verilmelidir." (MEB, 2013, p. XI).

The new high school mathematics curriculum summarizes the types of technological devices that can be utilized in mathematics education and instruction as follows: "Ortaöğretim matematik eğitiminde sıklıkla kullanılan bilgi ve iletişim teknolojileri şu başlıklar altında özetlenebilir: (dinamik) geometri yazılımları; grafik çizim yazılımları; elektronik tablo yazılımları; (grafik) hesap makineleri; akıllı tahta ve tabletler; elde taşınabilir veri toplama cihazları ve bunlara bağlanarak kullanılan algılayıcılar; bilgisayar cebir sistemleri; (dinamik) istatistik yazılım ve simülasyonları; oyunlar ve mikrodünyalar ve İnternet (WWW tabanlı uygulamalar ve sanal manipülatifler)." (MEB, 2013, p. XI). As it is clear from the foregoing sentence, dynamic mathematics software is among the technological devices that mathematics teachers are expected to use efficiently. However, efficient use of technology in mathematics education is directly related to the proficiency of mathematics teachers in such use.

The more professional at integration of technology into mathematics education mathematics teachers are, the more effectively and appropriately they benefit from such technology in their classrooms. Hence, appropriate trainings or at least opportunities should be provided to mathematics teachers to enable them to use dynamic mathematics/geometry software as an aiding tool in their classrooms. Such proficiency can make them change the classroom environment by using the said software, and be critical thinkers and consumers of the new pedagogies, as well as develop thought-revealing learning activities (Hacıömeroğlu, Bu, Schoen, & Hohenwarter, 2009).

**Mathematics teacher training**

In Turkey, YÖK is responsible for the standards and reconstitution of the teacher training programs. However, YÖK has not always been in control of the teacher education program. Degree from a higher educational institution instead of boarding schools or teaching schools has become a minimum educational requirement for being a teacher upon entry of the Basic Law on National Education into force in 1973 (Çakıroğlu & Çakıroğlu, 2003). This was followed by a second material change: YÖK introduced a unified higher education system, which shifted the responsibility for teacher education programs from MEB to HoCE (Çakıroğlu & Çakıroğlu, 2003).

YÖK determines the types of courses to be made available, and also arranges their contents. However, the courses determined by YÖK are not sufficient to achieve MEB's high school mathematics curriculum objectives. For example, objective 9.4.3.4. requires grade level 9 mathematics teachers to use compass, ruler or dynamic mathematics software to draw perpendicular bisector of a line segment. But a large portion of in-service mathematics teachers might not be able to achieve this objective as they do not have a formal training in using dynamic mathematics software. The assumption that the mathematics teachers could easily transfer their knowledge or skills of using a compass or a ruler to a dynamic geometry software and make quick manipulations seems to be far fetched.

In this study, it was aimed to develop contextual-based instructional worksheets to teach Turkish mathematics teachers GeoGebra. The most essential part of this study was that the content of the instructional worksheets was grounded in the MEB high school mathematics curriculum. Contextual-based instructional worksheets were drawn up to introduce properties of GeoGebra to mathematics teachers, taking MEB high school mathematics curriculum objectives into consideration.

## Problem

The new mathematics curriculum published by (MEB) clearly states and expects mathematics high-schoolteachers to use dynamic geometry software appropriately and efficiently in their lessons. However, the teacher training curriculum provided by YÖK fails to enable mathematics teachers to acquire necessary skills to meet the requirements announced by MEB. Because dynamic mathematics software is not yet a formal part of the teacher training program.

## Purpose

Mathematics teachers in Turkey were required to use dynamic mathematics software in their mathematics lessons appropriately and efficiently. To meet the requirements of MEB both in- and pre-service high school mathematics should learn how to use dynamic geometry software in their lessons. The purpose of this study is to develop contextual based worksheets to help high school mathematics teachers in learning how to use GeoGebra appropriately and efficiently.

## Significance

Although Turkish mathematics teachers are expected to use dynamic mathematics software effectively by MEB, mathematics teacher candidates take limited courses, or none, concerning dynamic geometry software. Due to the fact that teacher training programs published by YÖK do not cover specifically dynamics geometry software, it seems not a realistic goal to expect the teachers to use these tools in their classrooms. So, they are prone to teach as they are taught (Hacıömeroğlu, Bu, Schoen, & Hohenwarter, 2009).

Hence, the purpose of this study is to create contextual based instructional materials to help Turkish high-school mathematics teachers to learn the use of dynamic geometry software, GoeGebra.

By contextual based instructional worksheets, I refer to the fact that the mathematical content of the worksheets will be based on the official Turkish secondary school mathematics curriculum.

# CHAPTER 2: REVIEW OF RELATED LITERATURE

## Introduction

The purpose of this study is to develop contextual-based instructional GeoGebra worksheets for high school mathematics teachers. Existing literature was reviewed to present this study in the context of the studies conducted previously. This chapter aims to analyse the studies in relation to the study undertaken in this thesis under 4 main headings: *The effects of technology on schooling outcomes relating to mathematics education, GeoGebra as a dynamic mathematics software, Main terms and concepts associated with instructional design methods study and task analysis, Task analysis.*

## The effects of technology on schooling outcomes relating to mathematics education

This section summarizes a research article which includes meta-analysis of the recent literature on positive and negative impacts of technology use in teaching and learning mathematics. Through the meta-analysis the researchers tried to address two research questions: "What is the size of effects of technology on schooling outcomes in terms of mathematics education, and how does such size fluctuate in response to various study features (e.g. gender, age, and race) and design features (e.g. randomization, sample size, and instruments)?". 39 studies, which involved 59147 learners and yielded 81 independent findings, were analyzed. The results indicate that technology use has an impact on mathematics education.

Since this meta-analysis was carried out to reveal the effect of using technological devices in teaching and learning mathematics, the term "educational technology" plays a significant role in this study. Educational technology refers to technologic tools such as computers, calculators, educational software programs, interactive media, and telecommunication systems used in mathematics education.

Use of educational technology in elementary and secondary schools has been gradually increasing. Such increment on the educational technology stimulated the studies conducted to search for the effect of educational technology on mathematics education. With the developments in technological tools, the impact of the technological tools intended for mathematics education has become one of the most frequently studied research area.

As a result of the literature analysis, it was concluded that technology has an impact on teaching and learning mathematics. However, having such an impact does not mean that technology use ensures effective and meaningful learning and teaching of mathematics. Neither student characteristics and student group composition nor teaching methods can give the expected results from an education into which technology is integrated.

Mushi (2000) carried out a quantitative and qualitative research in eight schools in Chicago to evaluate results of integration of "Adventures of Jasper Woodbury" into a mathematics program developed by a team at Vanderbilt University. Quantitative analysis of the data collected from 1527 5th and 8th grade students indicated that "Adventures of Jasper Woodbury" mathematics program did not significantly contributed to knowledge, skills and attitudes of the students. Interestingly, the research showed that "Adventures of Jasper Woodbury" mathematics program contributed to a positive change on students' attitude towards mathematics, as learning mathematics through media attracted their attention.

Many teachers tend to use computer software in their lessons. Funkhouser's study (1993) on computer software programs suggested that computer software programs have a positive impact on secondary students' attitude towards mathematics. It also concluded that software programs contributed to problem solving ability and academic achievements of students.

Graphing calculators constitute another technological tool widely used in mathematics education. Jones (2005) claims that the research studies focusing on use of graphing calculators suggest that graphing calculators enable students to approach situations graphically, numerically, and symbolically simoutaneously. Students therefore can explore and visualize the situations, which they were not able to grasp otherwise.

In addition to the observations on technology's effect on mathematics education, the literatures indicated that the researchers also focus on examining effects of technology in mathematics education based on other factors. One of the listed factors was learning environment. Most of the studies investigated the results of two pedagogical approaches on students' learning on their own: traditional teaching and the constructivist methods.

In 1999, Shyu examined the effects of computer-aided and video-based instruction on students' problem solving skills and attitudes towards mathematics in a situated learning environment. The pilot study involved Taiwanese 6th graders. The researcher found that computer-aided and video-based instruction helped students to improve their problem solving skills; however, it failed to make noteworthy change on students' attitudes towards mathematics.

Another study was carried out by Connell in 1998 with the purpose of comparing the effects of technology in two rural classrooms, where either constructivist-based or behaviorist-based learning methods were used. As a result, performances of the students in the classrooms where the constructivist-based learning approach was adopted were considerably higher than the performances of those in the classrooms with behaviorist-based approach.

Xin (1999) examined effects of computer assisted instruction (CAI) in a cooperative learning environment. According to Xin's findings, cooperative learning environment combined with CAI increased students' mathematics performances. However, they could not decide if learning environment, CAI or the combination of both had a positive impact on students' understanding of mathematics.

Branden, Shaw and Grecko (1991) found that CAI had a positive impact on hearing impaired students' math quiz results but it had no effect on Florida Statewide Student Achievement math scores. However, the study of Cooper, Heron and Heward (1987) indicated that CAI helped the students with special needs to perform better and make more exact and correct calculations.

The most important conclusion drawn from this study is that gender and grade level constitute the two factors which have the strongest effect on mathematics education combined with technology. Regarding the gender factor, another interesting result is that technology has a positive effect on mathematics performance in female dominated groups compared to gender-balanced groups. And regarding the grade factor, secondary school students were found to learn considerably better than elementary students when technology was integrated into education.

Although contradictory results were reported above regarding the effects of educational technology on mathematics learning and teaching, the tendency is that technology had iğn general a positive effect on achievement and attitude. Especially if embedded in a constrcutivist learning environment.

## GeoGebra as a dynamic mathematics software

This particular dynamic geometry software is an ongoing attempt to design and to join advantages of different mathematics software types in one package, which then can be used in different mathematics contents, grade levels and teaching methods (Preiner, 2008). Besides GeoGebra, Cabri-géomètre, Cinderella, Interactive Geometry Software, Computer Lab Courseware, Geocadabra, Shapari and Curvay, and Geometry-Software-Dynamic are other examples of dynamic geometry and dynamic mathematics software used in mathematics education. A brief discussion follows about GeoGebra.

GeoGebra is an academic dynamic mathematics software derived from the master thesis of Markus Hohenwarter that started in 2001 (Prenier, 2008). GeoGebra is a commercial grade software that is under constent development and made available for free. Hence it is not a surprise that GeoGebra has a large number of users around the world (Lavicza, Hohenwarter, Jones, Alison, & Dawes, 2010; Hohenwarter, 2004).

For example, in 2013, it was used by teachers, students and researchers in 190 different countries, and it was translated to more than 50 languages around the world (Bulut & Bulut, 2011).

Another advantage of GeoGebra is that it is an open source for teachers and students (Lavicza & Papp-Varga, 2010). Thus, schools can install GeoGebra in their computers and use it in lessons without paying royalty fees. It is also accessible from everywhere by teachers and students. Moreover, GeoGebra can be easily upgraded when a new version is launched (Lavicza & Pap-Varga, 2010). New versions of GeoGebra are also free of charge.

GeoGebra is dynamic mathematics software which covers different areas of mathematics: algebra, geometry, calculus and statistics as an integral part (Lavicza, Hohenwarter, Jones, Lu, & Dawes, 2010). So, the users can easily reach different areas of mathematics in a single package.

Moreover, GeoGebra provides drag-and-drop support as a feature, which enables students to use real life images besides geometric shapes or angles (Pierce & Stacey, 2011). It is also concluded that by using GeoGebra, students can develop conceptual understanding and problem solving skills (Bulut & Bulut 2011). This conclusion is supported by Stojanovska and Stojanovski as well (2009). They point out the fact that GeoGebra helps visualize and explore (Stojanovska & Stojanovski, 2009). In a different way, GeoGebra dynamic mathematics software provides visualization of mathematical and geometrical terms (Hohenwarter & Fuchs, 2004).

## Main terms and concepts associated with instructional design method study and task analysis

The goal of this study was to develop learning materials for high-school mathematics teachers on GeoGebra. Therefore, well established instructional design principles had to be use in order not only to ensure the quality of the materials but also to provide a theoretical fundament for the processes utilized in the development. The following sections provides information regarding the main terms and concepts used in instructional design and will end with a description regrading the concept of task analysis and its important role in the overall development process.

**Education**

Education is a term which is used to describe all of the experiences that people learn (Smith & Ragan, 2005) These experiences are obtained either in a planned or an unplanned way. However, most frequently people learn in an unplanned way, incidentally and informally (Smith & Ragan, 2005). In this situation, there is no specifically arranged learning conditions or objectives which are intended to be achieved. Learners sometimes learn by trying and making mistakes. On the other hand, learning occurs when the process of learning is planned deliberatively and intentionally as well. The delivery of these focused educational experiences are called instruction (Smith & Ragan, 2005).

**Instruction**

"Instruction is the intentional facilitation of learning toward identified learning goals" (Smith& Ragan, 2005, p. 4). So it is the part of education where planning becomes the pillar or milestone. In order to achieve the goals, the learning environment which enables learners to get the new skill is arranged intentionally (Smith& Ragan, 2005). So, instruction can be defined as the intentional arrangement of the process of getting a new skill so that learners acquire particular capabilities. (Smith & Ragan, 2005)

In this study, tutors intend to teach inservice and preservice teachers, geometry dynamic software. Context based instructional materials were prepared to help inservice and preservice mathematics teachers in using it effectively. Before starting to prepare context based instructional materials, GeoGebra tutorial objectives were identified. It was intended to attain GeGebra tutorial objectives using context based instructional materials.

**Training**

Training refers to the instructional experiences which individuals focus on acquiring specific skills so that they will be able to apply these skills almost immediately in the near future (Smith & Ragan, 2005). Training focuses on giving a specific skill, since it is expected from the learners to perform the gained skill immidiatalty or not so far future. However, it is not always possible to provide training which aims to give information that is used immediately and completely.. One main barrier of course are previous learning experiences.

**Teaching**

Teaching refers to the learning experiences that are facilitated by a human being. (Smith, & Ragan, 2005, p. 6). This fact, is an important distinction between the term instruction and teaching. Here, not only lesson materials which foster teaching or learning are used, but also a real teacher plays a role in the teaching process. At this point, instruction and teaching differ from each other clearly. Instruction allows all of the learning experiences to be facilitated and supported through by teaching and other forms of mediation (self-paced learning for example).

**Relationship among terms associated with instruction**

Clearly, the term education and instruction do not refer to the same concept. Education involves instruction. Both of them intend to help learners get new skills but learning can occur naturally. In the below figure, the dark area, shows a pictorial representation between the difference of education and instruction (see Figure 1).

Instruction includes training. With Instruction and training provided for learners, learners acquire new skills. Both of them are provided intentionally and they are developed in a way intended to obtain specific objectives or goals. The point which differs training from instruction when the learnerss apply their new skills. After successful training the application of new skills are immidiaty. In the figure belwo, the white area, shows a graphical distinction between instruction and training.

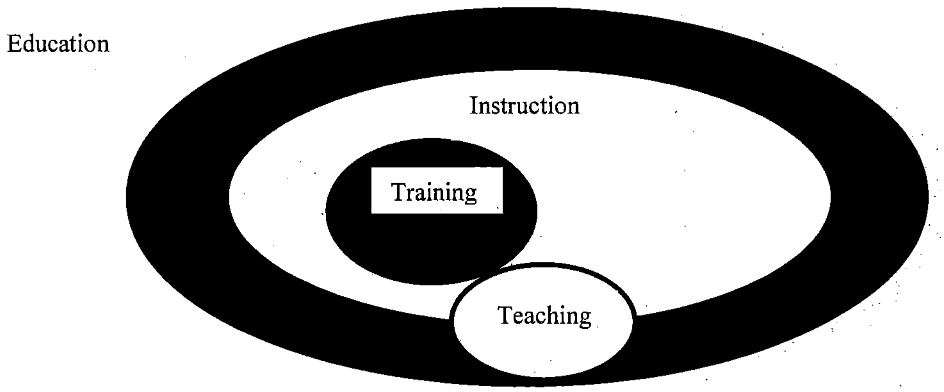


Figure 1. Relationships among terms associated with instruction (Smith & Ragan, 2005, p. 5)

**Task analysis**

"Task analysis for an instructional model is a process of analyzing and articulating the kind of learning and that you expect the learners to know how to perform" (Jonassen, Tessmer, & Hannum, 1999, p. 3). The following are the purposes of task analysis:

- To determine instructional objectives,
- To determine and explain the tasks and sub-tasks which students will deal with,
- To determine the type of information which will shape the task,

- To determine the priority and order of the tasks,
- To choose the appropriate media and learning environment
- To evaluate the performance and structure the evaluation. (Akkoyunlu, Altun, & Soylu, 2008). Actually, what kind of a process will be followed is shaped by achieving these process one by one.

Task analysis is the essential part of instructional design method. The reason is clearly understood from the itmes listed above. Moreover, task analysis actually comprise the biggest part of the instructional design method studies. During this process, questions relating to learning strategies, the learning environment, learning techniques and learning materials are tackled. (Akkoyunlu, Altun, & Soylu, 2008).

All task analysis are divided into five groups. They are Procedural Task Analysis, Hierarchical Task Analysis, Information-Procesing Analysis, Task Analysis For Attitude Goals, Task Analysis For Cognitive Strategy Goalsand Cluster Analysis.

**Procedural task analysis**

Unlike concepts and principles, procedural processes are defined based on rules (Akkoyunlu, Altun, & Soylu, 2008). Procedure steps may be so simple that students can easily follow them. However, there are complex procedures with many decision points that must be made by students. Difficulty level of procedures should not affect the procedural task analysis, and in turn, the success of students. Therefore, procedure steps must be planned linearly and sequentially.

According to Akkoyunlu, Altun and Soylu (2008), here are examples of learning goals, to which procedural task analysis is applicable:

- Changing a tire;
- Formatting a computer;

- Setting up a network;
- Creating a help file;
- Making a cup of tea.

*How to conduct a procedural task analysis?*

Figure 2 presents the steps to be followed to conduct a procedural task analysis.

Procedural task analysis processes generally include the four steps as follows:

- Determine whether a particular procedure is applicable,
- Remember steps of the procedure,
- Apply the steps in order, and apply decision steps, if necessary,
- Confirm that the result obtained is valid.

*Evaluation criteria for procedural task analysis*

Procedural task analysis can be evaulated based on the following criteria:

- Completeness: representation of all steps present,
- Writing down all steps using performance terms (using verbs),
- Suitability of procedural analysis for representing the task,
- Validity and accuracy: compatibility of the analysis with the actual task,
- Appropriateness of the flowchart or representation method – clarity and consistency of directional flow.

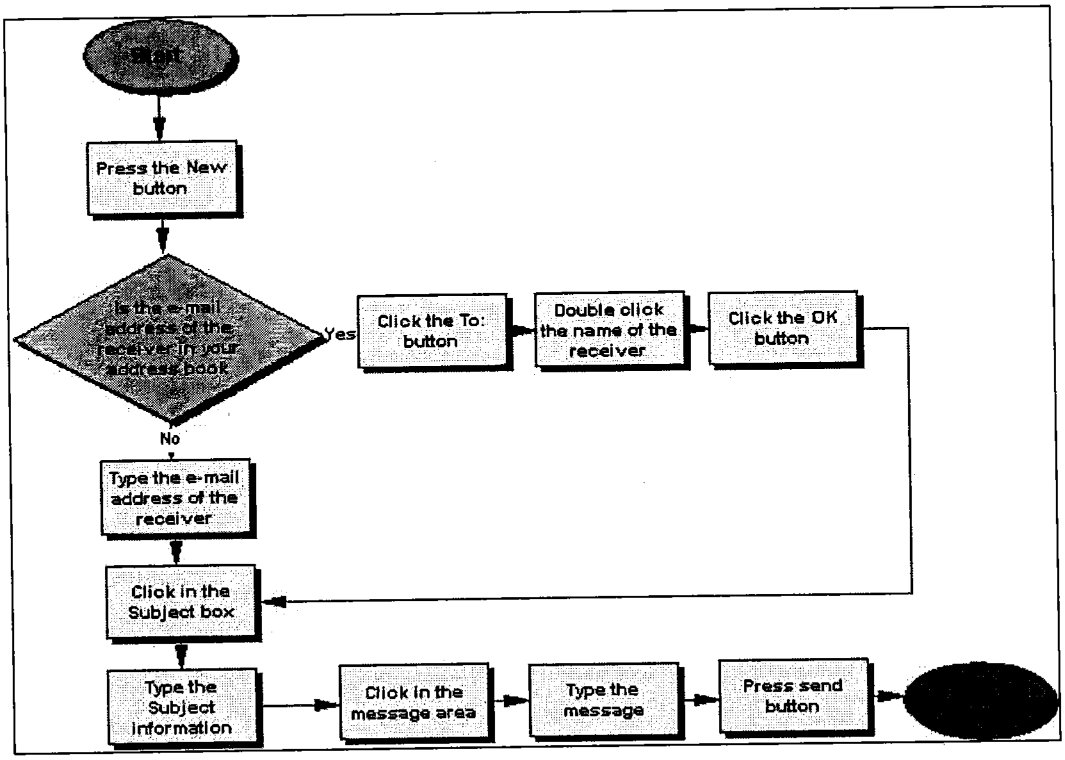


Figure 2. A sample procedural task analysis using a flowchart (Akkoyunlu, Altun, & Soylu, 2008, p. 121)

**Hierarcical task analysis**

Hierarchical Analysis is similar to functional job analysis. Here the researcher aims to establish prerequisites or thresholds. The goal is to predefine Learning Hierarchies (or Prerequisites). The learner hence, has to pass the thresholds before allowed to the next steps (Akkoyunlu, Altun, & Soylu, 2008). According to Akkoyunlu, Altun and Soylu (2008), the three following steps must be followed respectively to make a Hierarchical Task Analysis:

- The tasks are grouped or aggregated,
- To learn the tasks, the groups are arranged in a way that hierarchical relationships are figured out very well,
- An expert in its field must consult to make certain that task given in a hierarchical way are true (Akkoyunlu, Altun, & Soylu, 2008).

*How to conduct a hierarchical task analysis?*

Figure 4 presents the steps to be followed to conduct a hierarchical task analysis. Beginning a hierarchical task analysis by preparing a breakdown of all tasks is recommended. And hierarchy of the tasks should be constructed in the next steps. A three-step structure may be used to construct a hierarchy:

- Group/cluster the tasks
- Organize the tasks within each group in order to show the hierarchical relationships for learning
- Consult an expert in the relevant field to ensure accuracy of the hierarchy constructed (This step may be taken during the 1st and 2nd steps)

*Evaulation criteria for a hierarchical task analysis*

According to Akkoyunlu, Altun and Soylu (2008) the recommended evaluation criteria for a hierarchical task analysis are as follows:

- Adequate number of tasks present
- Depth of levels: whether the hierarchy is designed to ensure that each learning level leads to the final level of the task
- Validity and accuracy: how well the analysis corresponds to learning processes
- Ensure consistency in grouping similar tasks on same level in hierarchy
- Writing down all skills and sub-skills using performance terms (using verbs).

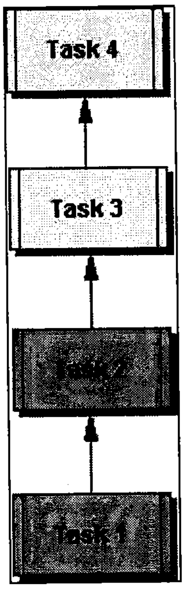


Figure 3. A hierarchical flow of charts (Akkoyunlu, Altun, & Soylu, 2008, p. 124)

Primacy-recency relation and sequencing are essential for a hierarchical task analysis since the tasks in such analysis are dependent on each other according to prerequisite relationships (Akkoyunlu, Altun, & Soylu, 2008). Tasks can only be performed from bottom to top. A structure similar to that shown in Figure 3 is applied.

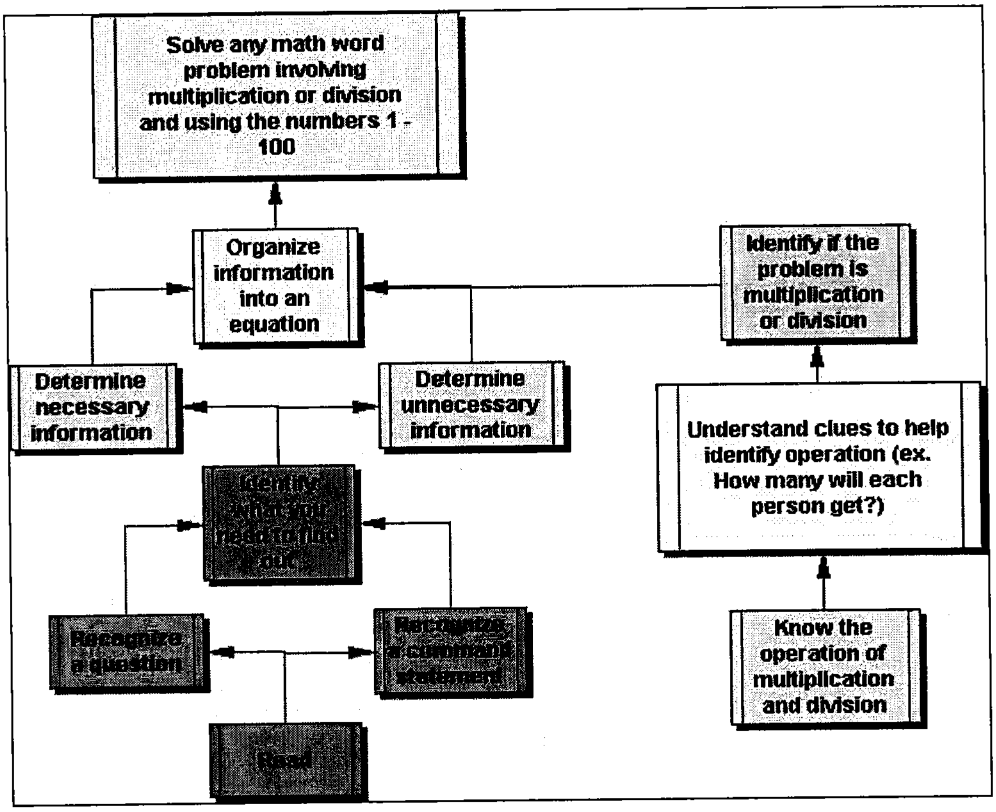


Figure 4. A sample hierarchical task analysis using flowchart (Akkoyunlu, Altun, & Soylu, 2008, p. 125)

**Information-processing analysis**

Preparing a breakdown of the goal to enable students to successfully achieve the goal is considered the first step of an information-processing analysis (Akkoyunlu, Altun, & Soylu, 2008). According to Akkoyunlu, Altun and Soylu when conducting this type of analysis, the question that must be kept in mind is "What are the mental and/or physical steps that someone must take in order to complete this learning task?" (see Figure 5).

*How to conduct an information-processing analysis?*

According to Akkoyunlu, Altun and Soylu (2008) an information-processing analysis is conducted by taking the ten steps below:

1. Collect as much information as possible about all concepts and the involved by the goal. Thus, you will become familiar with the relevant terminology. Then prepare the question groups that could be asked to an expert in the relevant field.
2. Rewrite the goal in the form of a representative test question.
3. Ask those who have thorough knowledge about the task, and do one of the following: a) observe them completing the task and ask them to describe their thought processes as they complete the task; b) write down, videotape, or otherwise record the steps they take in completing the task; c) ask them to write down the steps as they complete them; or d) ask them to write down even the simplest steps, which are not specified within the process but deemed important.
4. Review the steps recorded in step 3 above to increase your chances of finding out the unobservable cognitive knowledge that underlies the expert's behavior.
5. Review the common steps recorded by more than one expert in steps 3 and 4.
6. Identify the shortest and easiest way to complete the path, and note the factors that such simpler path requires.
7. Note the factors that may require more steps or more complex steps.
8. Choose the steps and cycles that leads to achieving the goal.
9. List the steps and decision points appropriate for the goal.
10. Consult other experts to verify the analysis.

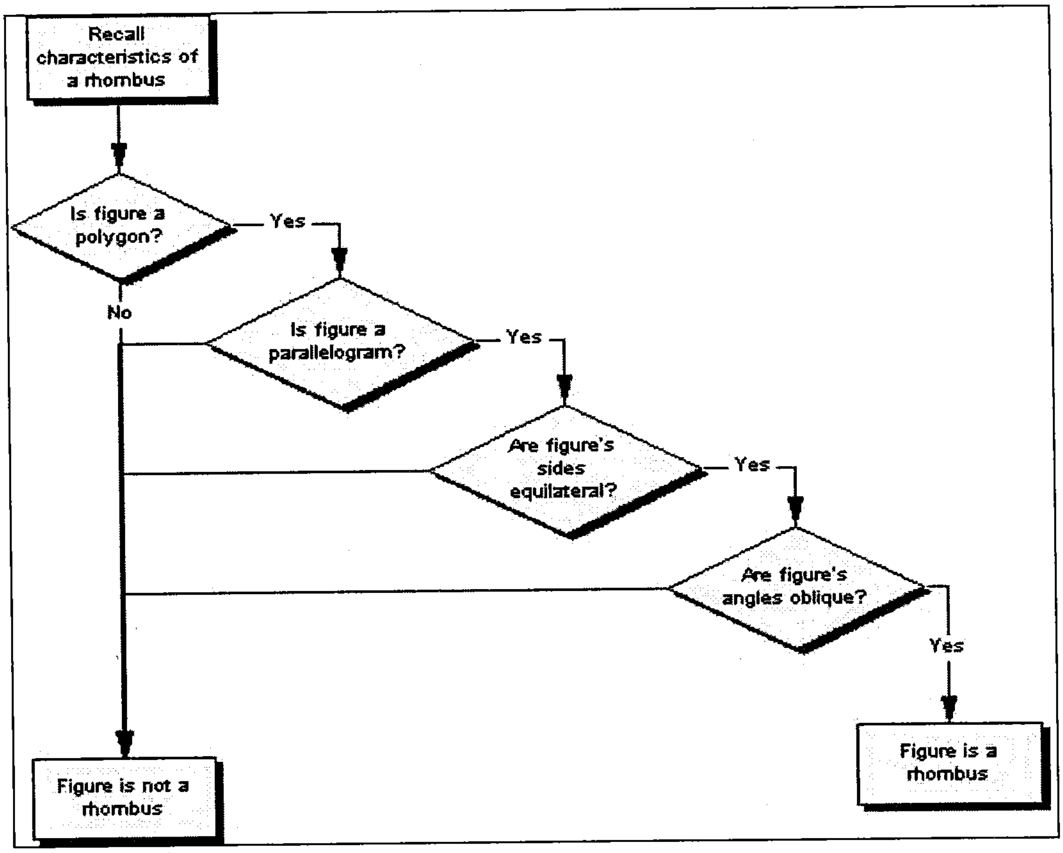


Figure 5. A sample information-processing analysis (Akkoyunlu, Altun, & Soylu, 2008, p. 127)

**Task analysis for attitude goals**

Attitudes play an important role in instruction, although they are not very often expressed as goals (Akkoyunlu, Altun, & Soylu, 2008). However, the studies relating to task analysis of attitude goals have not reached the desired level yet. According to Akkoyunlu, Altun and Soylu (2008), some of these studies suggest that there are 4 steps of task analysis for attitude goals:

- Evaluate the situation and take possible aspects of action into account,
- Determine the valuable aspect of the action,
- Choose the direction of a particular action,
- Take the action chosen.

To give an example for putting the foregoing steps into practice, the following goal may be set: “to resolve the conflicts that may occur in the class without resorting to violence” (Akkoyunlu, Altun, & Soylu, 2008). The steps to analyze the goal are as follows:

- Evaluate the conflict, and take possible aspects of action into account,
- Find solutions that do not involve violence,
- Choose behaviors that do not involve violence,
- Behave without resorting to violence.

A flowchart can be prepared for the foregoing steps (Akkoyunlu, Altun, & Soylu, 2008).

**Task Analysis for cognitive strategy goals**

Cognitive strategies cover the cognitive process and behaviors employed by students in order to complete a task or to learn (Boekaerts, 1999).

The task analysis for cognitive strategy goals is similar to a problem-solving analysis (Akkoyunlu, Altun, & Soylu, 2008). Steps of task analysis for cognitive strategy goals are structured as follows:

- Determine characteristics and requirements of learning task,
- Choose or develop strategies suitable for the task,
- Choose the most appropriate strategy,
- Use the strategy,
- Evaluate the effectiveness of the strategy,
- Keep using the strategy if it is effective; otherwise return to step 1.

**Cluster analysis**

"For goals within the verbal information domain, conduct an 'elaboration analysis,' or 'cluster analysis'" (Oliver, 2002, section 3, para. 3). A cluster analysis is used to analyze verbal information skills where no logical order is required to meet the stated goal(s) (Muffoletto, 2000).

*How to conduct a cluster analysis?*

The first thing an instructional designer should do before conducting a cluster analysis is to check whether there is a logical order between the verbal information (Akkoyunlu, Altun, & Soylu, 2008). If there is no logical order, the cluster analysis should be structured as follows:

- Identify the main concept,
- Determine how to structure the knowledge,
- Identify first-level headings, second-level headings, and so forth,
- Try to identify relations between the information to be taught.

**Summary of task analysis**

Task Analysis is the most important part of the instructional design meyhod studies. There are 6 type of task analysis. They are *Procrdural Task Analysis, Hierarchical Task Analysis, Information Processing Analysis, Task Analysis for Attitude Aims, Task Analysis for Cognitive Strategy Goals and Cluster Analysis.*It is the researcher who will decide which typeof task analysis is most appropriate for the study.

# CHAPTER 3: METHOD

## Introduction

The aim of this study is to create *contextual*-based instructional materials to teach dynamic mathematics software, in particular GeoGebra, to high school pre service and in service mathematics teachers. Instructional design method was used to achieve this aim. The following sections provide information about instructional design method under the heading "*Instructional Design Method*" and report on phases of the instructional design method study. The phases were *Problem Definition, Action Development, Detailed Design* and *Implementation and Evaluation.*

## Instructional design method studies

Instructional Design Method is used to solve instructional problems through a systematic analysis of conditions for learning (Seels & Glasgow, 1998). In order to solve the instructional problems, a systematic process is used to create education and training programs using consistent or reliable materials (Reiser & Dempsey, 2007). A systematic process refers to a vital process for conducting an instructional design methodsuccessfully. The systematic process covers planning of instructional systems, in which resources and procedures are arranged to promote effective learning (Seels & Glasgow, 1998; Gagne, Briggs & Wager, 1992). An answer can be found to the instructional problem through the instructional systems designed by using the instructional design method.

### General procedure of instructional design method studies

In the process of finding a solution to the instructional problem after it is defined, researchers analyze the problem, design a solution to the instructional problem, develop an instruction, employ the instruction, and then evaluate it. Briefly, the researchers, who employ instructional design method, analyze, design, develop, implement and evaluate an instruction. Therefore analysis, design, development, implementation and evaluation constitute common components of instructional design methods (Reiser & Dempsey, 2007).

### Common properties of instructional design method studies

The studies in which instructional design method is used are empirical, iterative, and self-correcting (Reisey & Dempsey, 2007) (see Figure 6). They are empirical because the data is collected and evaluated. They are iterative because going forward or back among the phases may be necessary. They are self-corrected because instructional materials are improved according to the feedbacks collected. Being empirical, iterative and self-correcting constitute the basic common characteristics of studies which employ the instructional design method.

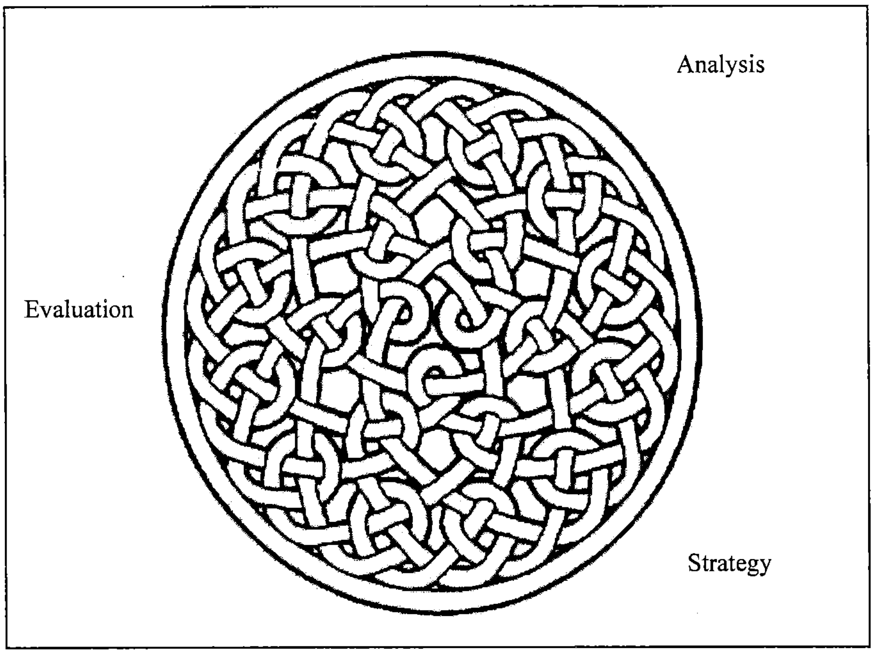


Figure 6. A more realistic representation of instructional design practice (Smith & Ragan, 2005, p. 5)

**Instructional design method studies are iterative**

A general procedure that can be modified depending on the properties of instructional design method studies is followed to carry out instructional design method studies. Four phases are completed to follow the general procedure of the study. Although, all of the instructional method design studies include the same four phases, what kind of a way will be followed to conduct the instructional design method study is changeable according to the properties of instructional design method study.

The first reason why the instruction design method is considered an iterative process is that proceeding consecutively or step by step by completing the phases is not a must due to the fact that instructional design method may require moving forward or going back among phases (Reiser & Dempsey, 2007). Therefore, conducting an instructional design method is considered an iterative process. In such iterative process, the researchers perform the same or similar tasks in order to improve their studies and make their instruction better, if necessary.

Ongoing improvement in the field of education constitutes another reason for considering the instruction design method an iterative process. As new contributions are made to the field of education on which the researchers worked, new needs or demands will arise because the researchers will try to find a solution for the current problem. In order to satisfy such new needs or demands, researchers need to change their previous studies turning their attention to the improvement in the field of education.

Researchers develop their instruction taking the current improvements in educational field into consideration. Hence, there is a room for the change of instruction every time because the needs or demands are changeable depending on the development in educational field that the researchers worked. Despite being completed, some phases may be reviewed and tailored to the improvements in the field of education, or skipping to previous phases or next phases before completing the phase on which the researchers worked is possible in order to make necessary changes considering current improvements in educational field. Thereby, the researchers will be able to develop an instruction which suits current problems best as a solution.

**Instructional design method studies are empirical**

The instruction developed will be applied for many years by those who need them. Thus, the instructional materials which are created under the instruction developed should be exact, correct, and should not contain any mistake in order to avoid addition of incorrect or improper principles, concepts or resources into the field of education. Hence, researchers should try to achieve the instructional problem through recently-developed, correct and suitable instructional materials.

Implementation and evaluation phase is extremely importantin terms of having accurate instructional materials. Therefore, instruction is implemented and evaluated after being developed. The implementation and evaluation phase covers collection and analysis of data and evaluation of the quality of instructional materials. The better data is analyzed and evaluated, the more the quality of instructional materials increase. Accuracy and relevance of the skills and knowledge to be taught can be ensured by providing guidance at implementation and evaluation phase (Reiser & Dempser, 2007).

**Instructional design method studies are self-corrected**

The aim of implementation and evaluation phase is to advance the instruction. In this phase, the researchers detect the deficiencies and weakly-designed aspects of the instruction, as well as those aspects that need to be improved. Following the implementation and evaluation phase, necessary are identified and whether the instruction is effective or not is made clear (Reiser & Dempser, 2007). Finally, instruction is transformed into a more advanced form by paying attention to the data collected at the implementation and evaluation phase.

## Instructional design method study

The overall process of this instructional design method study included various scientific steps as an integral part. How these phases were carried out was explained using two models. The first model displays the general procedure of the instructional design method study (see Figure 7). The second one illustrates the detailed procedure of the instructional design method study splitting each of the four phases into sub phases (see Figure 8).

**General procedure of the instructional design method study**

This section outlines what researchers did to complete the general procedure of the instructional design method study.The first model was used to illustrate the general procedure of the instructional design method study. The outline of the phases illustrated in the first model was explained in details by giving information about what researchers did to complete the four phases.

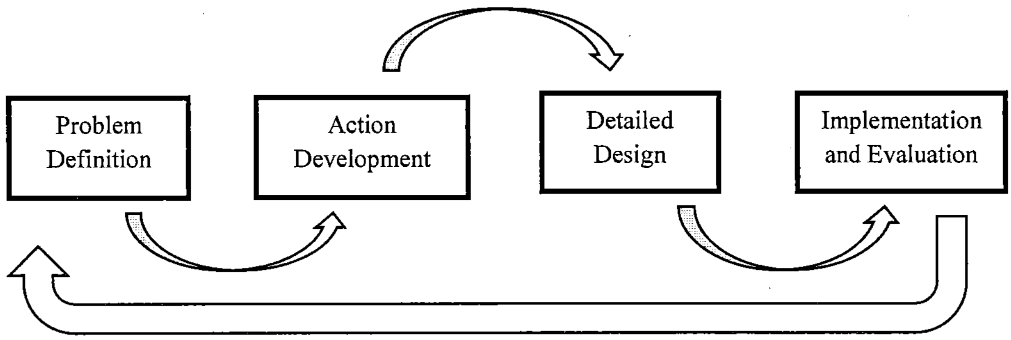


Figure 7. General procedure of the study

**Instructional problem of the instructional design method study**

This section gives information about the instructional problem which the researchers dealt with. The instructional problem handled by the researchers is described. Furthermore, why this instructional problem occurred is explained.

The instructional problem addressed in the instructional design method study is the contradiction between YÖK and MEB. MEB expects from high school mathematics teachers to use dynamic geometric software efficiently and proficiently, while YÖK supplies no course or limited course concerning the use of dynamic mathematics software, although high school mathematics teachers need to take such kind of of the instructional design method study splitting each of the four phases into sub phases (see Figure 8).

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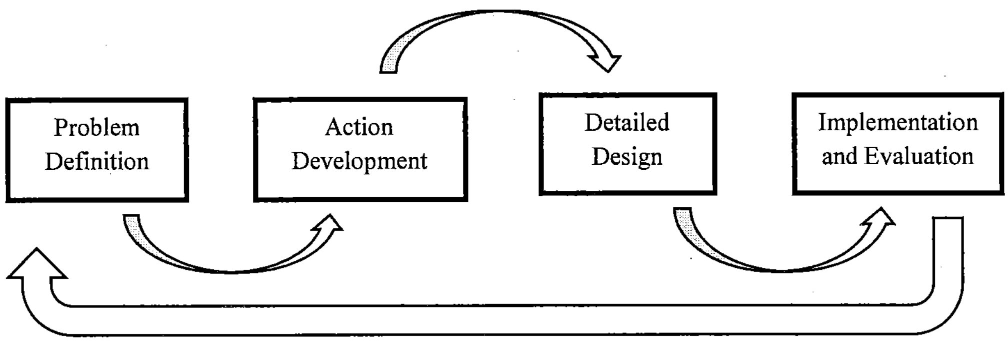


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### Finding the solution

This section covers information about the solution formulated by researchers to address the instructional problem given. Researchers focused on two basic concepts to solve the instructional problem. The first one was that high school mathematics teachers would be able to use GeoGebra dynamic mathematics software efficiently and proficiently. The second one was that high school mathematics teachers would adhere to the high school mathematics curriculum.

Taking these two concepts into consideration, the researchers decided to produce instructional materials that will enable high school mathematics teachers learn how to use GeoGebra to achieve the high school mathematics curriculum objectives. They also decided to arrange a GeoGebra training on using the said materials and evaluate their quality. The solution formulated by the researchers to address the instructional problem was to produce contextual-based instructional materials for high school mathematics teachers to make them use GeoGebra efficiently and proficiently.

### Deciding the systematic process to be followed

This section gives information about the systematics process followed to achieve the aim of this instructional design method study. The researchers arranged a systematic process based on the decisions made by them. They decided area of mathematics for which they will develop instruction, the instructional materials, implementation and evaluation of such instructional materials and GeoGebra training objectives. At the end of this long-term continuum, instructional materials that enable high school mathematics teachers use GeoGebra efficiently and proficiently were produced as it was planned previously.

**Decision on GeoGebra and area of mathematics**

This section covers information about the parts of GeoGebra and the area of mathematics, which the researchers aimed to study on. Researchers discovered affordances of the GeoGebra dynamics mathematics software. After learning affordances of GeoGebra, the researches selected one area of mathematics and carried out studies on that area.

GeoGebra is a dynamic mathematics software which contains geometry, algebra, tables, graphing, calculus and statistics as an integral part. Hence, it enables its users work more than one area of mathematics using only GeoGebra itself. Although some features of GeoGebra can be shared by two or more parts of GeoGebra, some features of it are added intrinsically as basic characteristics of such parts. The features which were not shared commonly make parts of GeoGebra different from each other.

In this study the researchers paid particular attention to one area of mathematics, namely geometry. The current features made GeoGebra reach its most suitable form to teach Geometry. Dr. Zsolt Lavicza, Dr. Zsolt Lavicza told in an interview on February 2014 that they had been working on the statistics part and algebra part of GeoGebra in order to improve them. He said: "Now, we have a new computer algebra part which is symbolic calculations. This is very important. We also have multiple windows. So, you can present several windows at the same time. I think statistics will be very important part of GeoGebra because it will happen that data analysis and then you can dollect data from physical objects, phones and different measurementals".

**Environment of the instructional design study**

This section provides information about the environment of the instructional design method studies. At first, information about what environment of an instructional design method means in general was given. Then, the environment of this instructional design method study is focused on.

The studies benefiting from the instructional design method are generally instructional problem-specific, because instructional materials are produced according to the sort of instructional problems and the needs of learners. A specific learning environment, which satisfies the needs of learners and the instructional problems, is created by the researches. The environment makes an instructional method design study different from any other study that uses instructional design method.

Environment means context, in which the learning and performing take place (Seels & Glasgow, 1998). Within the boundaries of the environment, the points that should be taken into consideration when advancing an education or training are found. These points are taken into account when determining the way of performing the instruction.

The environment of this study, which used instructional design method, comprises MEB high school mathematics curriculum and GeoGebra. The instructional materials for high school mathematics teachers are in coherence with MEB high school mathematics curriculum objectives and GeoGebra training objectives. It is safe to say that the environment of this study comes complete with MEB high school mathematics curriculum and GeoGebra training.

### GeoGebra training

A GeoGebra training was held by the researchers of this study. During the training, the instructional materials for high school mathematics teachers were put into action. The GeoGebra training made it possible to implement the instructional materials for enabling high school mathematics teachers learn using GeoGebra efficiently and proficiently.

### GeoGebra training objectives

This section gives information about the objectives of instructional design method studies and the objectives written for GeoGebra training. At first, information about the importance of and necessity of objectives is given. Then, information about how researchers wrote the objectives of this instructional design method study is provided.

The instruction designed plan requires to define objectives precisely (Seels & Glasgow, 1998) because of the fact that learners should be engaged in instruction in a comprehensive purposeful way (Gagne, Briggs, &Wager, 1992). If learners know what they are going to learn at the end of the activity, course or training, they can recognize the importance of their work and the expectation from them becomes clearer for them. Otherwise, learners cannot figure out the purpose of activity, course or training, or why they have to do it. For this reason objectives should be stated clearly.

At the beginning of this instructional method design study, objectives were defined clearly before starting to produce instructional materials for high school mathematics teachers and arranging a GeoGebra training. The researchers identified software properties of GeoGebra. They turned the software properties of GeoGebra into objectives. These objectives show what the users of instructional materials will achieve at the end of the GeoGebra training.

**Contextual-based instructional materials**

This section covers information about the instructional materials produced for this study. The instructional materials of this instructional design method study are 17 GeoGebra activities and 17 GeoGebra worksheets. In this section, the characteristics of these instructional materials were provided.

Instructional materials developed for and mentioned in this study for high school mathematics teachers are contextual-based instructional materials. GeoGebra training objectives were used as a guide for activities which were created to model the geometry topics Thus, the content of instructional materials for high school mathematics teachers depend on MEB high school mathematics curriculum objectives and GeoGebra training objectives. The context of instructional materials is decided by MEB secondary school mathematics curriculum objectives and GeoGebra training objectives. Therefore, it makes more sense to use contextual-based instructional materials instead of just simple instructional materials, because environment of study contains two different concepts, namely MEB high school mathematics curriculum and GeoGebra, and the instructional materials for high school mathematics teachers were prepared completely in connection with the objectives of the two different concepts.

*The reason for contextual-based instructional materials*

The main reason which leads researchers to develop contextual based instructional materials for high school mathematics teachers is that there are limited available resources from which high school mathematics teachers can use to learn how to teach geometry using GeoGebra efficiently or proficiently. The resources are generally released to teach how to use GeoGebra. The instructional materials which were generated for high school mathematics teachers in this instructional method design study and will be released in the future are based on two contexts rather than based on only one context, which are MEB high school mathematics curriculum and GeoGebra tutorial objectives.

**Participants**

The learners of and participants of this instructional method design study as well were first year pre-service mathematics teachers who have been obtaining their master degree in Curriculum and Instruction with Teaching Certificate master program at Bilkent University. In order to teach them to use GeoGebra dynamic mathematics software efficiently and proficiently, contextual based instructional materials for high school mathematics teachers were produced and they applied these contextual based instructional materials by themselves.

To know about their background technology knowledge, they were given 7 questions to answer. Their answers were illustrated by Table 1. Table 1 shows that only one of the teacher candidates had teaching certificate before enrolling at Bilkent University. The teacher candidate had no technology course when obtaining her teaching certificate. Even she applied for master program at Bilkent University to be a more proficient mathematics teacher in using technology as a result of the encouragenment of the researcher.The other 6 teacher candidates had not gotten teaching certificate. None of them heard nothing about GeoGebra and they did not know how to use GeoGebra. That is to say, before they started to learn how to use GeoGebra dynamic software, they had no experience about how to use it because they had no technology course related to GeoGebra use.

Table 1
Previous technology and GeoGebra knowledge of participants

| Participants | Teaching Certificate | Certification Courses about Technology Use | GeoGebra Knowledge Level | GeoGebra Use Level | Where did you hear about it | Where did you learn how to use it |
|---|---|---|---|---|---|---|
| Participant 1 | No | No Course | Never heard it | Never know | | |
| Participant 2 | No | No Course | Never heard it | Never know | | |
| Participant 3 | Yes | No Course | Just heard what it is | Never know how to use it | From Hamide Akkoca | |
| Participant 4 | No | No Course | Never heard it | Never know | | |
| Participant 5 | No | No Course | Never heard it | Never know | | |
| Participant 6 | No | No Course | Never heard it | Never know | | |
| Participant 7 | No | No Course | Never heard it | Never know | | |

**Learner centered education**

In instructional design method study, the focal point of all teaching and learning activities is learners and their performance (Reiser & Dempsey, 2007). That is to say, instructional design method promotes learner centered instruction. Self-passed study is one of the ways of applying a learner-centered instruction. In this type of learning, learners learn by themselves. They perform instructional materials by themselves and try to get the knowledge using instructional materials by themselves. At this point, learners and their performance become the crucial part of the instructional design method study.

The instructions take an important place in instructional design method because learners will only put their own effort to learn. The better instructions are written, the better learners understand what they will do. So, meaningful learning can be ensured via the instructions prepared properly and appropriately.

**Evaulation**

To assess the effectiveness of the contextual based instructional materials for high school mathematics teachers and reveal the discrepancies, a survey was created by the researchers. First year pre service mathematics teachers used a survey to evaluate the quality of the contextual based lesson materials. They also wrote feedbacks.

## Great significance of the study

In this instructional method design study the researchers focused not only to give the information of using the features of GeoGebra but also how these features can be used to teach meaningfully high school geometry topics. With the contextual based instructional materials for high school mathematics teachers, high school mathematics teachers will be able to teach geometry meaningfully using GeoGebra dynamic mathematics software within instructional method design study. Focusing on two contexts together makes this study different from the previous studies conducted to teach GeoGebra.

### Detailed procedure of the instructional design method study

Until this paragraph, information about what an instructional design method is and general procedure of this study has been given. Also, provided series of actions which were taken in order and how these actions were taken to perform this instructional method design study were given. The first chart was utilized to illustrate the general procedure of this instructional method design study.

The detailed procedure was told in the second chart (see figure 7). The detailed procedure involved the phases and the low phases of these phases operated by the researchers of this instructional method design study. These low phases were generated in a long process which the researchers hold discussions intensively and made up their mind carefully as a result of these intensive discussions. Hence, the researchers extracted, analyzed, organize and synthesized the information, which is a must to integrate such kind of behaviors to make an instructional design research method (Seels& Glasgow, 1998). The second chart provides the set of actions came to exist after extracting of, analyzing of, organizing of and synthesizing of the information.

In instructional design method studies, a number of similar tasks were conducted for each of these phases and a specific outcome is obtained (Seels & Glasgow, 1998). Second chart divided into 3 parts which illustrate these phases. These parts are *phases, activities* which the similar tasks were conducted and *outputs* which were obtained.

The *phases* part includes the phases which come from general procedure of the instructional method design study. These phases were split into lower phases under the main heading of *activities*. In these lower phases, the activities planned by the researchers were given step by step. The third part is *output*. In the third part, the researchers diagnosed what they obtained after they performed the previous two parts.

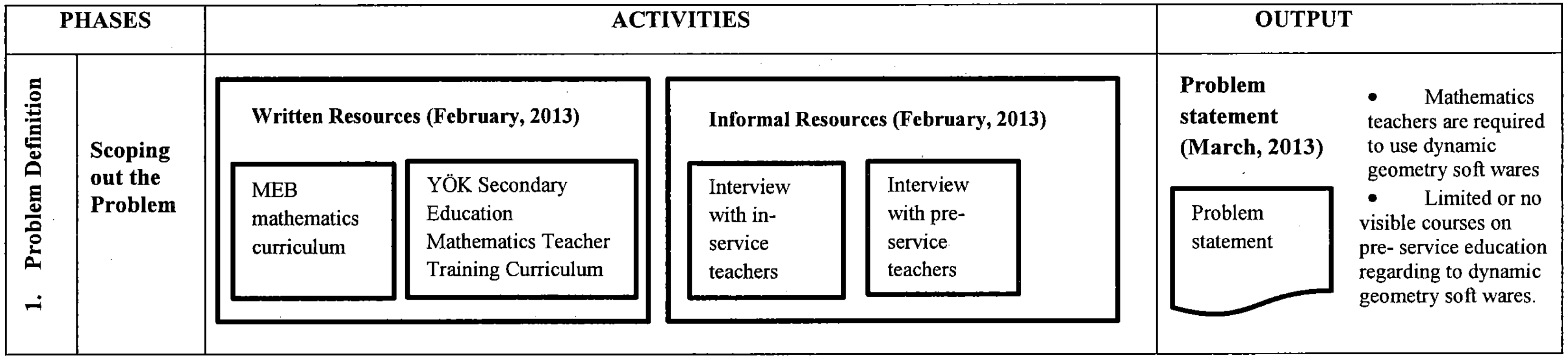


Figure 8. Detailed procedure of the study (cont'd).

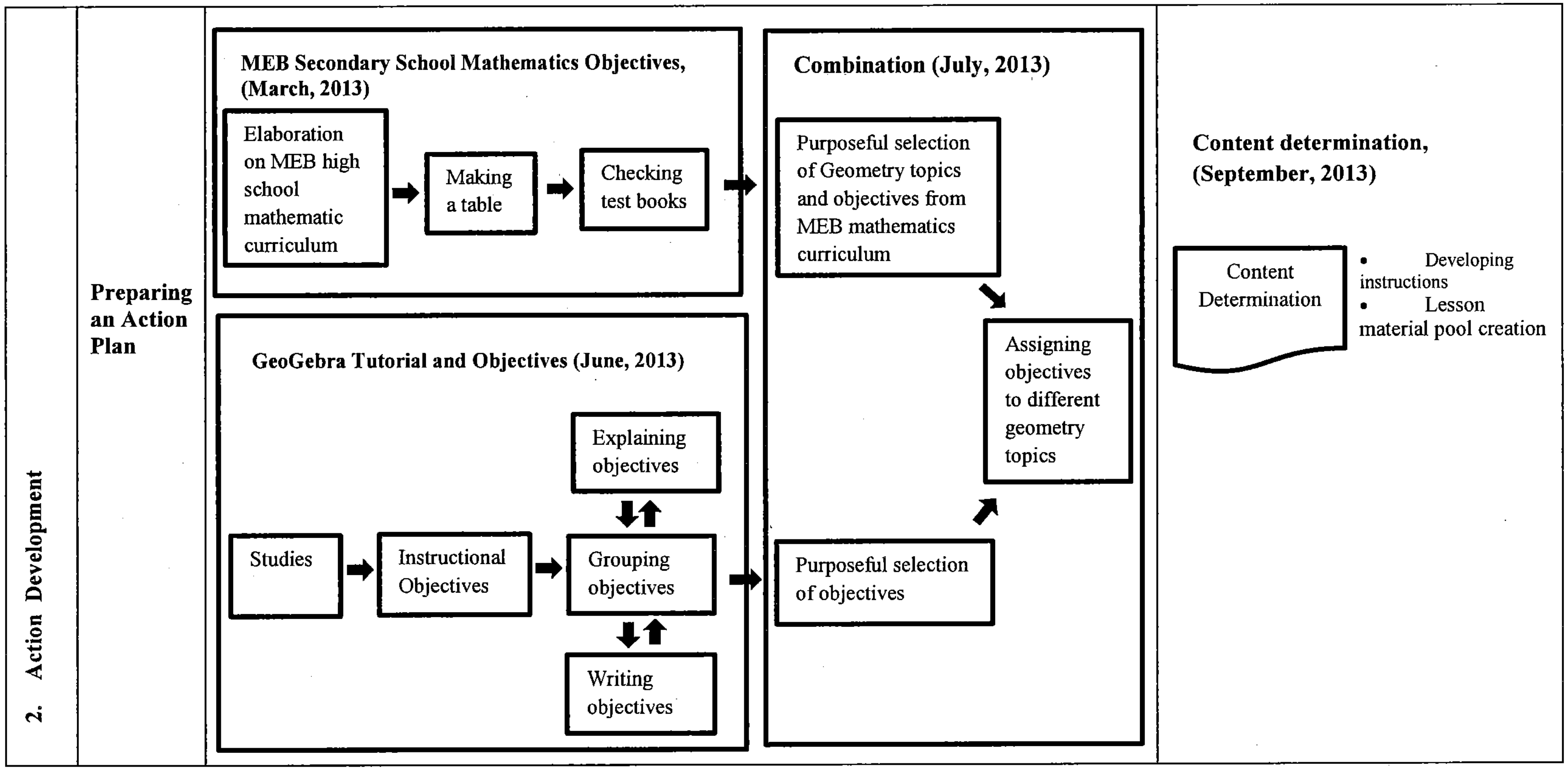


Figure 8. Detailed procedure of the study (cont'd)

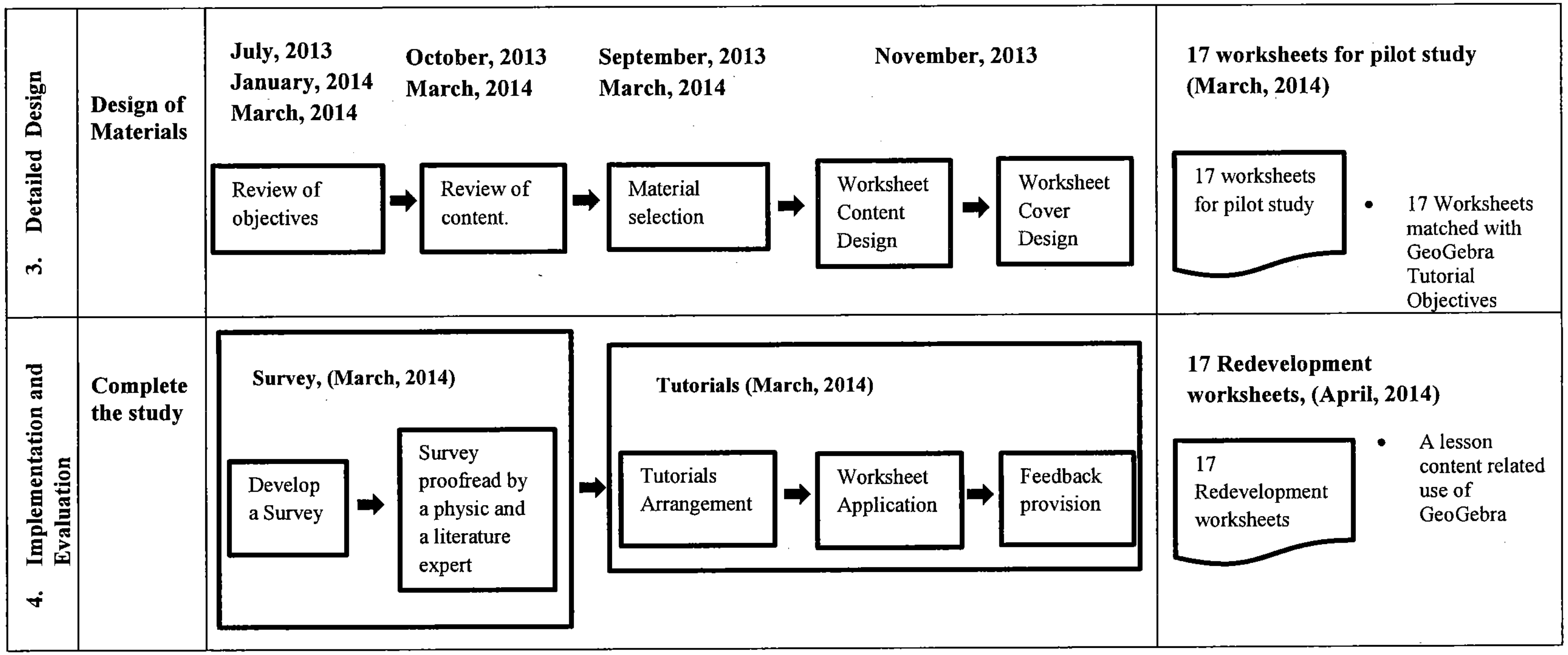


Figure 8. Detailed procedure of the study

## Problem definition

This section presents the process of describing the instructional problem. The researchers detected what caused the instructional problem existed. They revealed the gap MEB and YÖK, which causes an instructional problem. From the publication of the MEB high school mathematics curriculum to the formulation of the instructional problem, the process is given in this section. To make sure themselves that the gap really existed, they asked to other people to whom the study may concern.

### Scoping out the problem

The problem was scoped out after searching written resources out and working informal resources. Written resources are MEB high school mathematics curriculum and YÖK secondary education mathematics teacher training curriculum. When it comes to informal resources, they are interviews which were made with two pre-service teachers and two in-service teachers.

*Written resources*

In 2013, a new high school mathematics curriculum was published by MEB. In this new curriculum, MEB requires high school mathematics teachers to use efficiently and proficiently dynamic geometry software in their mathematics lessons. The main reason is that students can create their own geometrical drawings and also students can examine dynamically the geometrical shapes prepared by their teachers through dynamic geometry software (MEB, 2013). Hence, high school mathematics teachers need to be able to use dynamic geometry software efficiently and proficiently.

In Turkey, Higher Education Council is responsible for the curriculum of the high school mathematics teacher training programs at universities. But they provide no course or limited course concerning with the use of dynamic geometry software. Due to this, pre service and in service high school mathematics teachers need to be trained in using dynamic geometry software to use dynamic geometry software efficiently and proficiently.

This conclusion was drawn from the results of the analysis of MEB high school mathematics curriculum and of YÖK secondary education mathematics teacher training curriculum. In MEB mathematics high school curriculum it is stated that students can make examination dynamically over dynamic geometry shapes (MEB, 2013). It indicates that high school mathematics teachers are under the obligation imposed by MEB to use dynamics mathematics software in their mathematics lessons efficiently and proficiently. On the other hand, the facilities provided by HEC are not enough to meet the demand of MEB from high school mathematics teachers. It causes a contradiction between MEB and YÖK.

*Informal resources*

An interview was also conducted with the people whom concerned with this area. One type of interviewees are pre-service mathematics teachers. The interview was conducted by two pre-service teachers who had been receiving teacher training from different universities. The other type of interviewees are in-service mathematics teachers, who have been implementing high school mathematics curriculum at two different high schools.

According to one of the pre-service teachers, they got limited technology courses. They only learned to use the basic features of computer and combined them with mathematics topics. The other pre service teacher claimed that she got no course with regard to the use of dynamic mathematics software.

In the limited technology course, pre-service mathematics teacher was working out readymade online mathematics lesson materials. For example, they constructed concept maps to represent the relationships among the concepts or they were benefitting from the puzzle makers available in the internet. But these have no connection with dynamic mathematics software. The content of the course need to be enriched and involve some topics in the direction of the dynamic mathematics software use.

The in-service mathematics teachers had knowledge small in amount or had no knowledge about the use of dynamic mathematics software. Even they were not supported to have the information of using dynamic mathematics software that they can get by experience or study. Because of this reason they cannot use dynamics mathematics software efficiently and proficiently.

## Action development

In this section, it was told that the process which ended up with the solution generated by the researchers. The solution is the contextual based instructional materials which would be produced by the researchers. The draft of the contextual based instructional lesson materials were made ready after this section was finished.

### Preparing an action development

The action plan came out of consequences of two different studies conducted simultaneously on two different areas. One of them was the study on MEB high school mathematics curriculum objectives and the other one was the study on GeoGebra training objectives. After all these two studies were completed, worksheets were written by combining the results of these two different studies.

*MEB high school mathematics objectives*

MEB high school mathematics curriculum was examined in detail. The new curriculum mentions about the benefits of using dynamic geometry software in the mathematics lessons. It also gives suggestions to high school mathematics. For example, it tells the ways of using dynamic software in order to teach a few geometry topics interactively. The researchers came up with an idea that the same technique can be used for other geometry topics. In order to achieve what they intended, the researchers looked at carefully high school mathematics curriculum.

The focus was on geometry topics and lesson objectives of these geometry topics. A table was made to show clearly geometry topics and their objectives. The text books launched were reviewed and the most common question types were picked. So, geometry topics and common questions which satisfy the objectives were determined.

*GeoGebra tutorials and objectives*

GeoGebra is a dynamic geometry software which includes many different features as a part of it. In order to discover them, different geometrical shapes in Mathematics for Elementary Teachers were found out and they were drawn using the different functions of GeoGebra. Moreover, various geometry lesson materials were developed. Online teaching resources were reviewed to find out more about the features of GeoGebra.

All of the features of GeoGebra were written down. Each of these features correspond to one objective which are intended to achieve after the application of contextual based worksheets. All of the objectives were listed separately.

There are more than one way of doing some things in GeoGebra. For instance, a color of a polygon can be changed in 3 different ways. Making the users of contextual based worksheets realize it as well, the objectives were grouped. The objectives which end up with the same result were put together under one heading. These objectives were explained in detail. The steps were written respectively to show how these objectives will be operated and the same terminology was used not to confuse the readers.

Bloom Taxonomy was also taken into account to write the objectives. The instructional objectives were designed as learning outcomes at different classifications of Bloom's Taxonomy. Although most of the objectives are psychomotor objectives which users can physically able to do, some of them are affective objectives which are written about the attitudes of or feelings of users and some of them refer to the cognitive objectives which are about the skills and concepts which users can understand (Brahier, 2010).

*Combination*

Topics and objectives were selected purposefully.Objectives in connection with the features of GeoGebra were selected and they were used to achieve objectives in connection with Geometry. So, contextual based instructional materials for high school mathematics teachers were developed according to objectives of geometry lessons and of GeoGebra trainings.

The individual learning of first year pre-service mathematics teachers supported and activated through instructions designed (Gagne, Briggs & Wager, 1992). These instructions, which are needed to be followed to complete each of these GeoGebra activities, were developed and they were written step by step on contextual based worksheets. 21 worksheets in accordance with the 21 GeoGebra activities were written. At the end of this phase, a lesson material pool which included 21 worksheets, were created.

It was written how to do GeoGebra activites step by step on the contextual based worksheets. It was proceeded adding new features of GeoGebra to the next contextual based worksheets. At each of the contextual based worksheets, first year mathematics pre-service teachers learned at least one new features of GeoGebra. They need to learn the information given on previous contextual based worksheets well to be able to complete the next contextual based worksheet. That is to say the contextual based worksheets enable the users to make connection between their previous GeoGebra knowledge and new GeoGebra knowledge.

## Detailed design

The third sectioncame about because the contextual based instructional materials were not completed exactly and precisely. This section introduces the studies conducted to put the contextual based GeoGebra lesson materials in their last form. Until coming to the point which the contextual based lesson materials were finalized, proofread of the contextual based worksheets were made, grammar used to form contextual based worksheets was checked, the cover of and the content of the contextual based worksheets were designed. The information related to these parts were presented in this section.

### Design of materials

There are two important processes which must be considered definitely (Yanpar, 2006).They are designing instructional materials and preparing instructional materials. These two processes were finished in this third phase. At the end of this phase 17 contextual based instructional materials were made ready to use for the pilot study.

*Review of GeoGebra training objectives*

The objectives were reviewed by a physics education professor and a high school literature teacher. Physics education professor checked language used to explain the objectives and whether they were grouped correctly or not. High school literature teacher corrected typos and misspellings.

*Review of content*

The content was reviewed by two mathematics experts. One of the experts is a professor at university and the other expert is currently a middle school mathematics teacher. They checked whether the activities fits or not to the high school mathematics curriculum objectives or not.

*Material selection*

The number of the objectives assigned to the contextual based worksheets must be equal or close to each other.To make it happen, the activities in 21 worksheets were rearranged. If the number of the activitiesis enough, the activities remained on the contextual based worksheets. Otherwise, activities were taken out from the contextual based and distributed to the other worksheets.

As the time went by, GoeGebra had been developing and the new features had been adding to it. The content of the contextual based worksheets and GeoGebra activities were modified considering the developments in GeoGebra. It was important that the topics were taught by using the features of GeoGebra to which fit best.

Due to these two reasons, the contextual based instructional material pool changed frequently the latest form of the contextual based worksheets was created during this iterative process. Although there were 21 contextual based instructional materials in the beginning, there were 17 contextual based worksheets at the end.

In the table, it was illustrated that which contextual based worksheets have which GeoGebra objectives and which objectives were assigned to which activities (see Table 2, Table 3 and Table 4). The numbers in the first line refer to the MEB high school mathematics objective number. The numbers in the second line refer to the worksheet number and activity number. The first number is worksheet number and the second number is activity number. There is a dash line between the worksheet number and activity number. The numbers in the first column refer to the GeroGebra tutorial objective number.

Table 2
The number of activities, objectives in worksheet 1, worksheet 2, worksheet 3, worksheet 4, worksheet 5 and worksheet 6 and objective distribution

| Worksheets | W1 | W2 | W3 | W4 | W5 | W6 |
|---|---|---|---|---|---|---|
| Number of activities | 1 | 3 | 2 | 1 | 1 | 2 |
| Number of activities in each of the activities | 1(16) | 1(2)<br>2(2)<br>3(9) | 1(6)<br>2(12) | 1(11) | 1(16) | 1(13)<br>2(6) |
| Sum of Objectives | 16 | 13 | 18 | 11 | 16 | 19 |

Table 3
The number of activities, objectives in worksheet 7, worksheet 8, worksheet 9, worksheet 10, worksheet 11 and worksheet 12 and objective distribution

| Worksheets | W7 | W8 | W9 | W10 | W11 | W12 |
|---|---|---|---|---|---|---|
| Number of activities | 2 | 2 | 4 | 2 | 3 | 1 |
| Number of activities in each of the activities | 1(2)<br>2(3) | 1(3)<br>2(11) | 1(1)<br>2(4)<br>3(1)<br>4(3) | 1(4)<br>2(5) | 1(3)<br>2(5)<br>3(2) | 1(9) |
| Sum of Objectives | 5 | 14 | 9 | 9 | 10 | 9 |

Table 4
The number of activities, objectives in worksheet 13, worksheet 14, worksheet 15, worksheet 16 and worksheet 17 and objective distribution

| Worksheets | W13 | W14 | W15 | W16 | W17 |
|---|---|---|---|---|---|
| Aktivite Sayısı | 2 | 4 | 1 | 4 | 8 |
| Number of activities in each of the activities | 0(8)<br>1(4)<br>2(1) | 1(2)<br>2(3)<br>3(4)<br>4(3) | 1(15) | 1(2)<br>2(8)<br>3(3)<br>4(4) | 1(2)<br>2(1)<br>3(0)<br>4(0)<br>5(1)<br>6(1)<br>7(7)<br>8(4) |
| Sum of Objectives | 13 | 12 | 15 | 17 | 16 |

*Worksheet content design*

To make the users recognize GeoGebra terms, GeoGebra terms were italicized. Negative words or expressions were underlined. In addition to these, the same words were used to explain one expression instead of using different words which have a similar or a related meaning to create coherence. The pictures of the icons and of other important GeoGebra elements were used to support the written expressions.

*Worksheet cover design*

Cover of the contextual based worksheets was designed by the researchers. Researchers put GeoGebra icon and the ordinal number of the contextual based worksheets, information regarding to the history of GeoGebra, the name of and contact information of researchers were put on the worksheet cover. Cover page is the first page.

## Implemenation and evaluation

This section was existed to expand on the process which the contextual based instructional materials were implemented and evaluated. After all 17 contextual based instructional materials were completed, they needed to be implemented to make certain that the contextual based lesson materials worked well, to find out the mistakes done unintentionally and to identify the instructions need to be modified or changed. The first year mathematics pre service teachers implemented the contextual based worksheets and they evaluated them using a survey developed specifically for this study by the researchers.

### Complete the study

As well as creating contextual based GeoGebra files, contextual based worksheets were developed as written materials to explain how to create these GeoGebra files. In order to ensure the further development, these lesson materials must have been evaluated before the training and after they were used (Yalpak, 2006). Before the training, contextual based GeoGebra activities and worksheets were evaluated by people from different areas as it was understood from the third phase. In addition to this, contextual based instructional materials were also evaluated by first year pre service mathematics teachers after they were used by them in the GeoGebra tutorials.

*Survey*

There are many prepared check lists which are regarded ascriteria to evaluate written resources.The researchers did not apply ready-made criteria.Instead, they prepared a brand new survey peculiar to and appropriate to the contextual based instructional materials of this instructional method design study.

In order to prepare the survey, researchers benefitted from a survey developed by Yaprak (2006). It was a survey developed to evaluate books. 3 criteria which were taken into consideration to evaluate the features of a book also fitted to the features of the worksheets. These criteria were copied but the other criteria were created by the researchers themselves.

The survey questions were prepared in 7 different dimensions so the quality of the worksheets was calculated from seven different angles (see Table 5). The survey questions were categorized under 7 headings. The headings were contributions of contextual based activities to achieve cognitive and psychomotor objectives, contributions of contextual based activities to achieve affective objectives, physical properties of contextual based worksheets, accuracy of information, the use of language, manner of telling and coherence with MEB.

Table 5
Grouping survey questions

| Survey Question Types | GeoGebra Tutorial Objectives |
|---|---|
| Contributions of contextual based instructional materials to achieve cognitive and psychomotor objectives | 2.1, 2.2, 2.3, 2.4, 3.1, 2.14, 3.2, 2.19, 3.4, 2.25. |
| Contributions of contextual based instructional materials to achieve affective objectives | 2.7, 2.8, 2.11, 2.19, 2.20, 2.21, 2.22,2.23. |
| Physical properties of contextual based worksheets | 1.1, 1.2, 1.4, 1.5, 1.6, 1.7, 1.9, 1.10, 3.8. |
| Accuracy of information | 1.8, 2.12, 2.14, 2.15, 2.16, 3.5, 1.21, 2.27. |
| The use of language | 1.11, 1.12, 1.14, 1.15, 1.16, 1.17, 1.19. |

Table 5.
Grouping survey questions

| | |
|---|---|
| Logic sequence of instructions | 1.18, 1.20, 1.21, 2.4, 3.8, 3.6, 3.4, 1.13, 3.9. |
| Coherence with MEB. | 2.8, 2.9, 3.12, 2.11, 2.17, 3.10, 2.25, 2.26. |

After the survey was finished completely, it was considered by a high school literature teacher and a middle school teacher to make changes if necessary. The high school literature teacher and middle school mathematics teacher made a proofread. They also checked whether the survey questions fell into the correct category or not.

*Tutorials*

GeoGebra tutorials were arrangedwith the aim of teaching GeoGebra through contextual based instructional materials. The tutorials were given at Bilkent University as a part of MT 503 Computer Technology in Mathematics Education. The tutorials took ten hours which corresponds to two and a half week. They were managed by the researchers.

At the beginning of the tutorial, a presentation was made. The aim of the presentation was to introduce the purpose of study to first year pre service mathematics teachers and explain the expectations from them. After the presentation, tutorials started.

In these tutorials, first year pre service mathematics teachers did the activities on the worksheets by themselves. However, the researchers were also with them although they must do activities by themselves. The researchers did not leave first year pre service mathematics teachers all alone by themselves due to the fact that they wrote down the questions and feedbacks provided by first year pre service mathematics teachers.

When first year pre-service mathematics teachers were busy with activities, they gave written feedbacks. After they completed worksheets, they evaluated worksheets in terms of seven different angles by filling the survey given to them. The contextual based instructional materials were evaluated individually.

According to the feedbacks obtained from first year pre-service mathematics teachers, necessary modifications on contextual based instructional materials were made. Contextual based instructional materials were rearranged. 17 redeveloped instructional materials were obtained at the end of the instructional method design study.

### The outcome of the instructional design method study

The purpose of this instructional method design study was to produce efficient and proficient contextual-based instructional materials for teaching high school mathematics pre-service and in-service mathematics teachers GeoGebra. Only pre-service teachers were used to evaluate the contextual based instructional materials. However, high school pre-service mathematics teachers and in-service mathematics teachers will benefit from the outcomes of this instructional method design study.

# CHAPTER 4: RESULTS

## Introduction

This chapter start with a brief overview about the learning object determination of GeoGebra and the match procedure between the GeoGebra learning objectives and MEB high-school geometry mathematics curriculum. Then, the written feedbacks of the seven pre-service mathematics teachers are provided in detail. The resulting feedbacks were grouped in three main categories. The chapter concludes with the descriptive statistical analysis of the data collected through the survey.

## Method of data analysis

The first section of this chapter describe the framework establishment processes for which the contextual based instructional materials were created. The goal was to match the contextual based instructional materials in accordance with MEB mathematics high school curriculum. They were evaluated using a survey. The following sections *Matching Process and Data Analysis* will provide information about how GeoGebra Tutorial Objectives and MEB objectives were matched and the results of contextual based instructional materials analysis.

### Matching process

The matching process basically involved two main steps. The first step was the creation of GeoGebra learning objectives and the second was to create a table of content that listed a cross match between each MEB high school mathematics objectives with GeoGebra learning objectives. The resulting tables of content formed the bases for the creation of contextual based GeoGebra instructional materials.

*GeoGebra tutorial objectives writing process*

The process of writing GeoGebra learning objectives started in June 2013 and ended in March 2014. The process started first by dissecting and listing every single feature of GeoGebra pertaining to the subject of Geometry. As many modern software applications do, GeoGebra too, provides the user with alternative ways. To accomplish the same task. Therefore the need to create grouping was necessary in order to match features pertaining to the same group of task. For example, to place a "point", the user can use the following methods:

1. Main Menu: Tools → Point Tools → Point
2. Click on the point then click on the desired location
3. Use the input bar and enter the coordinate values for the point to be created.

The end result for all of the above listed processes will be the same, namely the creation of point. During this time, new versions of GeoGebra was released and as a result new features were available. Those new features were either added to the list or revised. Needless to state this process was an iterative process. After the finalizing the tables of content, the constraints for the contextual instructional materials were materialized.

*Assigning objectives to the activities*

The content that comprises the contextual based instructional materials are based on the MEB's national mathematics high school curriculum. Towards that 17 worksheets have been developed in order to cover both national high school mathematics curriculum and to master basic GeoGebra skills.

Depending on the main objectives of most of the contextual based worksheets have more than one activity that the teachers need to follow in order to master materials.

The number of activities in each of the contextual based worksheets is not equal to each other. 5 of 17 contextual based worksheets have only one activity. 12 contextual based worksheets have more than one activity. Only 5 out of 17 contextual based worksheets have only one activity.

*Matching GeoGebra tutorial objectives with MEB objectives*

Selection of the GeoGebra tutorial objectives was the thing which was taken careful note. GeoGebra tutorial objectives were selected and matched with MEB high school mathematic curriculum objectives, which fit best to the MEB high school mathematic curriculum objectives. Only if the best GeoGebra tutorial objective, which fits best, is selected, MEB high school mathematics curriculum objectives were obtained meaningfully.

In the table, it was illustrated that which objectives were assigned to which activities. The numbers in the first line refer to the MEB high school mathematics objective number. The numbers in the second line refer to the contextual based worksheet number and activity number. The first number is worksheet number and the second number is activity number. There is a dash line between the worksheet number and activity number. The numbers in the first column refer to the GeroGebra tutorial objective number.

It was proceeded adding GeoGebra tutorial objectives to the next contextual based worksheets. GeoGebra tutorial objectives, which were achieved by applying the contextual based worksheets for the first time, matched with MEB secondary school mathematics curriculum objectives which take place in these worksheets. However, GeoGebra tutorial objectives were not taken into consideration, which were not achieved for the first time by applying contextual based worksheets.

## Data analysis of worksheets

This section presents the results of data analysis for each worksheet. The data were collected through written and oral feedbacks, and a survey which was provided by first year pre-service mathematics teachers enrolled in the 2013-2014 academic year at Bilkent University. The results of written feedbacks and then descriptive data analysis were succinctly reported.

### Written feedbacks for each worksheet

Every worksheet was evaluated by seven pre service mathematics teachers one by one. What seven pre service mathematics teachers obtained as a result and what they mentioned for authors to consider were given under the title of *participant 1, participant 2, participant 3, participant 4, participant 5, participant 6* and *participant 7*. Under the sub titles, the feedbacks were labelled using three numbers. The fist number represents worksheet number, the second number reperesents participant number and the third number represents feedback number.

#### Contextual based worksheet 1

This worksheet has only one activity. The main goal of the worksheet is to introduce the user to interface and related main widow components. The idea of object by creating a rectangle and manipulating some of its features (see Appendix B for all related objects).

*Participant 1*

**1.1.1**One part of this activity provided step by step information about how use the labeling options. Further in the activity the participants were required to use the skill again.But this time less information regarding the steps were given. According to participant 1 the second part where labeling options was requested again needed to list all the steps again.

**1.1.2.** The user requested to put a point randomly on the graphics window. Participant 1 commented to specify the locations of points to be placed on the graphics window. She believes that will create less confusion.

**1.1.3.** Similar to the above comment, the line segment creation feature procedure should be explained with location data.

**1.1.4.** While doing this activity the pre service mathematics teachers changed the location of algebra window of GeoGebra accidentally. As a result, the pre service mathematics teachers suggested to that this feature should b e a part of the first worksheet activity.

*Participant 2*

**1.2.1.** Participant 2 commented that the descriptions provided in activity 1 were too detailed. According to her, the descriptions needed to be lessen.

*Participant 3*

**1.3.1.** A part of this activity explained the 6 different ways possibilities of using "redo" and "undo" feature. Participant 3 found this exercise confusing and commented that not all the different ways of doing "redo" and undo" should be included in one activity.

*Participant 4*

**1.4.1.** Participant 4 suggested to add the following information "GeoGebra is a tool which is used to support mathematics education" on to the cover page at the activity. The cover page included brief information regarding GeoGebra.

**1.4.2.** In order to manipulate any object displayed on the graphics window, one has to select it first. Participant 4 commented on this fact by emphasizing that directions should be included in the activity regarding the initial selection of an object prior manipulating it.

*Participant 5*

**1.5.1.** Participant 5 hided the algebra window of GeoGebra accidentally. She could not display it again. So, participant 5 suggested that window display property (show or hide) should be provided on the first worksheet.

*Participant 6*

**1.6.1.** GeoGebra offers 4 attributes for labeling options (automatic, all new objects, no new objects and new points only). At a later point on the worksheets, the participant 6 required to recreate new objects with labeling. The labeling directions text made a reference to make it clearer by referring to the operations attribute directly.

**1.6.2.** At one point, Participant 6 encountered problems while trying to drag and change the location of a point that had a fixed location attribute. Although the steps for reaching the fixed, semi-fixed and free points were explained at earlier stage on the worksheet she suggested to include this information over and over.

*Participant 7*

**1.7.1.** She too commented about the directions regarding the labeling options. She made similar comments and provided similar suggestions as participant 6.

**1.7.2.** Participant 7 too provided feedback about the selection process of objects.

**Contextual based worksheet 2**

This worksheet has three activities. The main goal of this worksheet is todevelop the understanding of the relationship betweenpoint colors and point movability, to attributes related to the selection of objects and attributed for hiding or showing objects.

*Participant 1*

Participant 1 did not provide any feedback.

*Participant 2*

**2.1.1.** Instruction 11 activity 1 required the users todrag point A on the Graphics view.She suggested warning the users so thatthey become aware of the fact that none of the objects were selected on the Graphics view except point A.

**2.1.2.** Participant 2 had difficulties in identifying the sequential numbering labeling schema used by GeoGebra for texts.

**2.1.3.** She corrected one misspelling.

*Participant 3*

**2.3.1.** Similar to Participant 2, Participant 3 also suggested to add a warning related to the selection of objects.

*Participant 4*

**2.4.1.** Participant 4 corrected the wrong location description of Graphic window. In instruction 1 activity 1 required the users to find "Graphic" word at the right top of the Graphic window. But "Graphic" word is at the left top of the Graphic window.

**2.4.2.** Participant 4 pointed out that whole polygon must be selected to be able to drag it on the Graphics window.

*Participant 5*

**2.5.1.** Participant 5 reported that she could not move the points.

**2.5.2.** Similar to Participant 4, Participan5 too reported that she could not drag the polygon on the Graphics view.

*Participant 6*

**6.2.1.** Participant 6 did not make any comment.

*Participant 7*

**2.7.1.** Participant 7 suggested that text labeling schema of GeoGebra must be explained.

**2.7.2.** Participant 7provided feedback about instruction 3 activity 1.According to this instruction, after selecting the polygon iconand clicking on the board, on a line segment would appear on the Graphics window. However, it appears after completing the whole polygon.

**Contextual based worksheet 3**

Two activities comprise this worksheet. The main goal was to introduce objects creation using icons and object attributes manipulation including the graphics view.

*Participant 1*

**3.1.1** She provided only one critique. She found that some sentences discerning and the directions too long. One point of attribute is "attach and detach". She found this attribute to be unnecessary.

*Participant 2*

She did not make any feedback.

*Participant 3*

She did not make any feedback.

*Participant 4*

**3.4.1** Participant 4 suggested to change the orders of instructions. The instruction described where to locate the points created. Her suggestion was to move this instruction at the very beginning of the activity.

**3.4.2.** The instruction suggested to intersect lines. This skill was introduced at an earlier stage. There are three different ways to accomplish intersection between lines in GeoGebra. Based on the path, the user choses a different labeling schema which will be used by GeoGebra and the resulting labeling display might look slightly different since the directions on the worksheet did not ask for a particular way to create the intersection. Participant 4 suggested that it should be mentioned otherwise the end result might not look the same as worksheet. She commented that this might lead to a name confusion especially for novice users.

**3.4.3.** When typing comments, GeoGebra automatically prompts the user with a generic syntax for that comment. The worksheet too, included generic GeoGebra syntax about a comment, and then the actual comment needed to be type was also provided in the directions. According to participant 4, it is unnecessary to write the generic syntax of the commands. The directions should only include the actual information that needs to be typed. GeoGebra follows the rules of standardized notation used in mathematics used in Mathematics. For example, capital letter donate points where small letters refer to lines. At this point, participant 4 lacked the knowledge of this basic information.

*Participant 4*

Participant 4 did not made any comment.

*Participant 5*

Participant 5 did not made any comment.

*Participant 6*

**3.6.1.** Many straight sided closed 2 dimensional plane shapes are referred as polygons. The polygon icon needs to be selected first to create a polygon. The ending process i.e. finalizing a polygon involves by clicking on the very first created point. Participant 6 suggested it to explain it.

*Participant 7*

**3.7.1.** Participant 7 pointed out that in order to drag a point it should be clearly mentioned in the directions to first select the point.

**Contextual based worksheet 4**

The main goal of worksheet 4 is about text creation and manipulating related attributes. This worksheet has only one activity.

*Participant 1*

**4.1.1.** Participant 1 struggled with the term "radio button" which was used in the directions. She suggested to provide definition of what a radio button is at the beginning of the worksheet.

**4.1.2.** GeoGebra uses two different notations for text labels of lines. The worksheet directions used the same notations displayed in the algebra window. Participant 1 got confused because she used the notations created on the Graphics window. In the graphics window, a line is displayed like $\overline{AB}$ whereas the algebra window refers to the same line as textAB.

*Participant 2*

**4.2.1.** The worksheet directions refer to the menu icons via numbers which were provided in worksheet 1. Participant 2 suggested to use relative location names for example the last group as last icon instead of the twelfth icon.

*Participant 3*

**4.3.1.** Worksheet 1 & 2 included exercises regarding the different possible selection options of objects (e.g. triangle, side of a triangle, etc.). Participant 3 commented that the selection process steps in this worksheet should be restated again. She wrote that the side can be selected for example from algebra window.

*Participant 4*

Participant 4 did not make any comment.

*Participant 5*

**4.5.1.** Participant 5 faced similar problems as participant 1. She too had difficulties relating the naming schema between the graphics window and algebra window. The graphic window displays the distance between point A and B as $\overline{AB}$ whereas the same information is displayed as textAB in the algebra window. She too had similar problems relating this two information and commented that this fact need to be stated in the worksheet.

**4.5.2.** In GeoGebra manipulations of objects can be done in several different ways. Besides selecting an object and then following a wizard (point and click) command line input are also allowed. If a user decides to use the command line feature, GeoGebra will provide list of possible commands including a general syntax about how to use the command while the use types the intended command. For example user can change the background color of an object by typing the following comment into the input, Set BackgroundColor[ <Object>, "<Color>" ]. Participant 5 was under the impression that the actual object name would be displayed as well. Hence, she searched the specific command for the object that she intended to manipulate. Only after realizing that the notations are general guides provided by GeoGebra. She suggested that the worksheet needs to include exact substitution information as well.

*Participant 6*

**4.6.1.** Participant 6 encountered similar naming problem as participant 1 and participant 5.

**4.6.2.** Participant 6 also made suggestion about the selection of colors. In worksheet 4, it is expected from the users to make the color of line segments dark green. Participant 6 could not find dark green among the colors offered in GeoGebra. Since participant 6 could not find the color, participant 6 suggested to use green to change the color of line segments.

*Participant 7*

**4.7.1.** In worksheet 4, it was required from the users to find the interior angles of the rectangle. Participant 7's resulting angles labeling was different from the worksheet. Participant 7 suggested that labels should match.

**4.7.2.** Participant 7 also made a general comment regarding the activities provided in worksheet 4. According to her, there is no need to change the color, to change the size of texts or objects. Participant 7 commented that they are unnecessary information since she learned how to do them before. Participant 7 suggested that the activity could include more mathematical knowledge instead of GeoGebra knowledge.

**Contextual based worksheet 5**

This worksheet has only one activity. The main goal of this worksheet was to reinforce the skill acquired in worksheet 4 by using the following geometric objects; point, line and circle.

*Participant 1*

**5.1.1.** Participant 1 pointed out two written statement mistakes.

*Participant 2*

Participant 2 made no comment.

*Participant 3*

Participant 3 made no comment.

*Participant 4*

**5.4.1.** Participant 4 provided feedback about the use of *Set Line Thickness slider.* As the slider goes to the right side, the line thickness increases. There are ticks representing the units on the slider but the ticks have no numerical values attached to them. Participant 4 made a comment that she struggled with the slider to make the line thickness 9. So, participant 4 suggested that a picture of Set Line Thickness slider must also be included with the verbal statement.

*Participant 5*

**5.5.1.** Participant 5 too had similar difficulties as participant about "Set Line Thickness slider".

*Participant 6*

Participant 6 did not provide feedback.

*Participant 7*

Participant 7 did not provide feedback.

**Contextual based worksheet 6**

This worksheet included two activities. The main goal of the activity was to teach that object attributes could be treated as variables. By doing so instant changes could be made to objects.

*Participant 1*

**6.1.1.** In GeoGebra object's information can be displayed in two distinct ways. The first one utilizes automatic naming of object attributes and the second one uses the independent "text object" by assigning the object to be displayed as a variable. The first activity included an example and step by step procedure of how to accomplish this on a circle. The second activity asked for the same procedure. Participant 1 encountered difficulties with the second example that had less procedure information on an angle. Participant 1 encountered difficulties with the second example that had less procedural information by commenting that more detailed procedural information needs to be provided in order to accomplish this task successfully.

**6.1.2.** When creating text objects, GeoGebra uses a similar sequential numbering labeling schema as for all other objects (these names can be used as variables names later on). The labels created for text objects are not directly displayed. Only when the user hovers on the "text object" the label name pops up. Participant 1 encountered problems while trying to identify the correct "text object" on the graphics window that the instructions asked her to do. Only after verbal explanation she was able to continue on with the activity.

**6.1.3.** Footnotes were used in this worksheet for further explanations. The footnote marks were subscribe numbers. These let to a confusion of the concept of "power of". Participant 1 pointed this fact out. The same footnote marks were also used in the previous worksheets.

*Participant 2*

**6.2.1.** Participant 2 had problems finding the "Miscellaneous" option. She recommended to provide a better description as far as the procedural informations were concerned.

**6.2.2.** Participant 2 restated that the worksheets should use relative naming for icon rather than referring to them with numbers. She made this suggestion earlier as well.

**6.2.3.** The worksheet included leading and trailing spaces for the angle commend which resulted in an error. Participant 2 pointed this mistake out.

*Participant 3*

**6.3.1.** The users were required to construct a circle using the "circle with center through a point" icon. These procedural information led to a second unnecessary point creation, instead the "circle with a center and radius" icon should have been used which would have avoided this issue. Participant 3 pointed this out.

**6.3.2.** Participant 3 too had problems finding the Miscellaneous option. She also recommended to provide a better description as far as the procedural informations were concerned regarding these particular steps.

**6.3.3.** A part of the activity required the user to change initially the size of a text object and after that change the thickness of the text object. Both use similar steps but participants were required to do them separately. Participant 3 suggested to combine these two tasks as one task.

**6.3.4.** Participant 3 too pointed out the leading and trailing spaces mistake for the angle command.

*Participant 4*

**6.4.1.** Participant 4 provided feedback about explanation of constructing a circle thorough "circle with a center through a point" icon as participant 3 did.

*Participant 5*

**6.5.1.** Participant 5 too provided feedback pointed out he labelling and trailing spaces mistake for the angel commend.

**6.5.2.** Participant 5 put a comment about the grammar used in worksheet 6. According to participant 5, the thickness of a point is not true explanation and size of points must be used in the place of thickness of a point. Concerning the grammar used in worksheet 6, participant 5 also corrected the misspelling of the words. Apostrophe was not put correctly, there was a blank between the apostrophe and the text, part word was not written correctly and back was written instead of background. Participant 5 corrected them and wrote a comment about them.

**6.5.3.** Participant 5 put a pointed out that the description of the location of Miscellaneous was wrong. The Miscellaneous was referred in the graphic window. However its correct location is in the Basic window which is inside of Graphics window.

**6.5.4.** Participant 5 gave feedback about the selection of colors. There are two color boxes, one of them is rectangle while the other one is square. In worksheet 6, the colors were expressed using their codes not with their names. But it was hard job to find the codes of the colors among all of the color codes. Due to this, participant 5 suggested to express the colors not only by rows but also by columns.

**6.5.5.** Participant 5 corrected misspelled word.

**6.5.6.** Participant 5 suggested that command words written in a different style.

**6.5.7.** Participant 5 too pointed out the leading and trailing spaces mistake for the angle commend.

**6.5.8.** Participant 5 gave feedback about dragging property of GeoGebra. In worksheet 6, the users were required to construct a ray and create a point on this ray. To be able to drag the ray, the users must click on the point and drag the point so that the ray will be dragged at the same time as well. Participant 5 suggested to include this fact in the procedural descriptions.

*Participant 6*

**6.6.1.** Participant 6 had no particular comments.

*Participant 7*

**6.7.1.** Participant 7 provided a feedback about thedescription of the location of *Miscellaneous* part.

**6.7.2.** Participant 7 wrote a comment about the selection of colors. In worksheet 6, it is told that the color with the code of 255, 255 and 102 is on the third row. Participant 7 wrote that she could not find where the color with the code of 255, 255 and 102 was.

**Contextual based worksheet 7**

This worksheet has two activities. The main goal was to provide procedural knowledge about finding distance between two points, the median of triangles and being able to change related attributes.

*Participant 1*

**7.1.1.** Participant 1 put a comment about a writing error regarding to labelling. She corrected the mistake.

**7.1.2.** Participant 1 provided feedback that her label names of angles were different than those on the worksheet. As a result, she pointed out that she had difficulties following the worksheet.

*Participant 2*

**7.2.1.** Participant 2 provided feedback about an instruction number 10. According to participant, instruction number 10 was very long. She stated that it makes it hard to follow.But she did not provide any suggestion on how to change it. This particular instruction briefly introduced the Latex notation and the directions on how to apply the syntax on GeoGebra.

*Participant 3*

**7.3.1.** She pointed out the same error as participant 1 did.

*Participant 4*

**7.4.1.** The syntax Vector[ <Point><Point> ] was used, whereas the correct syntax should have been Vector[ <Start Point><End Point> ]. Participant 4 pointed this mistake out.

*Participant 5*

**7.5.1.** She also pointed out the same error as participant 1 and participant 3 did.

**7.5.2.** The users were required to change the back ground color of the text object but a specific color is not given.Participant 5 put a comment about it.

**7.5.3.** Participant 5 put a comment about the footnotes in worksheet 7. Participant 5 wrote that the number of footnotes confused participant 5 because they look like exponential numbers. According to participant 5, another footnote notation was required to prevent possible confusion. This concern was mentioned earlier as well.

**7.5.4.** Participant 5 gave a feedback about direction number 10 where they were required to use *Latex* notation (e.g. /sqrt{x}). Detailed written expressions were provided. She too had similar problems as participant 2 following the written directions.

**7.5.5.** Participant 5 pointed out that angle bisector icon was referred as the third icon on the tool bar. However it should have been referred as the fourth icon.

**7.5.6.** As participant 1 did, she pointed out that her label names of angles were different than those on the worksheet. As a result, she pointed out that she had difficulties following the directions on the worksheet.

**7.5.7.** Participant 5 had difficulties with intersect the objects. This was a skill taught in earlier worksheets.

*Participant 6*

**7.6.1.** Participant 6 provided feedback about how to find the angles. In worksheet 7, it is wanted from the users to find the interior angles of a triangle but it was not mentioned about if the direction of clockwise or the direction of the reverse of anticlockwise should be followed to find the interior angles of triangles. Participant 6 wanted it to be written. GeoGebra follows standard mathematical notations.

*Participant 7*

She did not make any comment.

**Contextual based worksheet 8**

This worksheet had two activities. It is a reiteration on the median concept of geometric shapes and it also introduces the centroid concept.

*Participant 1*

**8.1.1.** The syntax Distance [ <Point>, <Point> ] was used whereas the correct syntax should have been Distance [ <Point>, <Object> ].

*Participant 2*

She did not provide any feedback.

*Participant 3*

**8.3.1.** The users were required to display the following notation on the Graphics window. In order to accomplish this, one has to use the following expression. This skill was taught in earlier worksheets but she did bot remember it and needed help.

**8.3.2.** She provided feedback that her label names of objects were different than those on the worksheets. As a result she pointed out that she had difficulties following the worksheet at this stage she should have known by now that GeoGebra creates automatic sequential names for objects. So, if label names are different than those on the worksheet, this is the cause of the steps that are not in the worksheet or the omission of steps.

*Participant 4*

**8.4.1.** The syntaxDistance[ <Point>, <Point> ] was used whereas the correct syntax should have been Distance[ <Point>, <Object> ].

*Participant 5*

**8.5.1.** The syntaxDistance[ <Point>, <Point> ] was used whereas the correct syntax should have been Distance[ <Point>, <Object> ].

**8.5.2.** It was required to find the distance between two points. There are several ways to accomplish this task. She preferred to use the command line input. While doing, the distance information is displayed in the algebra window. Not on the graphics window. One has to enable the visibility attribute [check "show" ]. She commented that this fact should be provided [activities regarding hide/ show were done numerous time up to this point].

**8.5.3.** Participant 5 commented about the numerical display of a result of a division. The decimal notation of numbers can be defined in GeoGebra, she missed this point.

**8.5.4.** Participant 5 wrote instruction 7 used "iki kere tıklayın" by this term was wrongly used. She pointed this out.

**8.5.5.** She too pointed out that her label names of objects were different than those on worksheets. As a result, she pointed out that she had difficulties following the directions on the worksheet.

*Participant 6*

**8.6.1.** The syntaxDistance[ <Point>, <Point> ] was used whereas the correct syntax should have been Distance[ <Point>, <Object> ].

*Participant 7*

Participant 7 did not provide any comment.

**Contextual based worksheet 9**

4 activities comprise contextual based worksheet 9. The man goal of this worksheet is to introduce new window feature of GeoGebra to the users, make them use the attributes of GeoGebra related to reflecting, rotating, and translating.

*Participant 1*

**9.1.1.** She pointed out one misspelling and corrected it.

*Participant 2*

Participant 2 did not provide any comment.

*Participant 3*

**9.3.1.** She pointed out two misspelling and corrected them.

**9.3.2.** In instruction 7 activity 4the users were required to create a polygon using the given points. However, it was not given that in which orders the points are going to be joined. Participant 3 wrote a feedback about it and added that participant 3 could not continue because the order was not given.

*Participant 4*

**9.4.1.** The "next" word was misspelled. She pointed this out and made correction.

*Participant 5*

**9.5.1.** Point A was required to be crated on a random location. She pointed out that point A should not be on y=4, this fact should be stated and included in the instruction.

**9.5.2.** In this worksheet, the users are required to reflect about the point but it was not told how to do it. According to participant 5, although it was given in previous worksheets, it must be written one more time to remind it.

**9.5.3.** The word "rotation" was misspelled on the worksheet. She pointed this fact out and corrected it.

*Participant 6*

Participant 6 did not make any comment.

*Participant 7*

**9.7.1.** As participant 5, participant 7 too pointed out that her label names of objects were different than those on worksheets.

**Contextual based worksheet 10**

This worksheet was composed of two activities. The main goal is to manipulate geometric objects that in involved more complex geometrical patterns such as tessellation.

*Participant 1*

**10.1.1.** Instruction 16 activity 2 required her to reflect a polygon over a vector. She stated that she could not accomplish this task. Although the concept of reflection and needed skills were explained in previous items about a point, she could not transfer this particular knowledge to a polygon.

*Participant 2*

Participant 2 did not make any comment.

*Participant 3*

**10.3.1.** The first item asked the participants to hide the axis on the graphics window. The next instruction tells its users to create two point with specific coordinate values. Participant 3 wrote that she could not do it without axis. Using the input command line any object can be placed on to the graphics window.

**10.3.2.** Participant 3 pointed out a mistake on the worksheet. In instruction 16 activity 2, it was stated to reflect a polygon over a vector. Participant 3 pointed out correctly that the term "reflect" should be actually "translate".

*Participant 4*

Participant 4 did not make any comment.

*Participant 5*

**10.5.1.** As participant 3, participant 5 too had problems with creating a point without axis display on the graphics window.

**10.5.2.** Participant 5 pointed out a misspelled word on item 14 activity 1.

**10.5.3.** Participant 5 pointed out a mathematical syntax error in item 1 activity 1. A dot between the x coordinate and y coordinate values of point D was used instead a comma.

**10.5.4.** As participant 3, she pointed out the erroneously used term "reflection". The correct term should have been "translate".

**10.5.5.** She pointed out that wrong menu should have been "View".

**10.5.6.** As participant 3, participant 5 too Participant 5 pointed out the wrong term use in instruction 17 activity 2.

*Participant 6*

Participant 6 did not make any comment.

*Participant 7*

**10.7.1.** Participant 7 encountered label naming problems.Hence, she gave up trying to complete the activity.

**10.7.2.** Participant 7 reported feedback about the use of colors. According to participant 7, the use of color function of GeoGebra is not extremely important. Participant 7 was unhappy with the use of color properties of GeoGebra.

**10.7.3.** Participant 7 made a comment about the mathematics used in these activities. "Matematiksel işlevi çok güzel oluşturulmuş. Oluşturulan desenler ve öğeler ilgi uyandırıcı". An interesting comment especially regarding her resistance to learn the visual attributes of objects.

**Contextual based worksheet 11**

This worksheet is composed of three activities. The main goal is to introduce the "slider" properties of GeoGebra. GeoGebra keeps tracks of every user made input, which then in return can be manipulated for presentational purposes. A handy feature for teachers, especially for demonstration purposes in teaching.

*Participant 1*

**11.1.1.** She commented that some instructions are very long. Activity 1, instruction 42-49. All items were one sentence long. But the task at this point involved several steps to accomplish it successfully.

*Participant 2*

**11.2.1.** Verbal description was provided for the location of the "slider" icon. She expressed that icon picture of slider icon should be added to the text.

**11.2.2.** Participant 2 correctly suggested to use the radio button term instead of the term circle.

**11.2.3.** She reported that she could not locate the *Rotate around a Point* icon.

*Participant 3*

**11.3.1.** She pointed out that she was not able to use the *Fix Object* attribute.

**11.3.2.** Participant 3 pointed out a mistake. Corner 3 was referred to mistakenly, it should have been Corner 4.

*Participant 4*

**11.4.1.** She commented that she had problems with the label of objects. Her names would not match those on the worksheets.

*Participant 5*

**11.5.1.** She suggested to add "Table of Contents" page. All previous worksheets had a table of contents page.

**11.5.2.** She pointed out the task describing segment creation missed the information regarding the direction missed, item 18 activity 1.

**11.5.3.** Participant 5 wrote down that the name of the points were not same as with label names of points in the worksheets.

**11.5.4.** Participant 5 reported the wrong file name. The users were required to record their studies in folder named as Worksheet 9 instead of worksheet 11.

*Participant 6*

Participant 6 made no comment.

*Participant 7*

Participant 7 made no comment.

**Contextual based worksheet 12**

Worksheet 12 has only one activity. The main goal of this worksheet is to introduce spreadsheet to the users.

*Participant 1*

**12.1.1.** Participant 1 provided feedback about the wrong interval of angles. In worksheet 12, an angle slider is created between 0° and 90°. Participant 1 wrote that she could not create a slider because she did not remember how to create it. After learning how to create a slider, she suggested to change the interval. The angle slider must get values between 0° and 360°, not be between 0° and 90°.

**12.1.2.** Participant 1 stated that she could not complete the activity because of the label name mistakes between those shown on the worksheet and her study.

**12.1.3.** Participant 1 requested to remind how to use input bar to calculate the trigonometric ratios.

*Participant 2*

Participant 2 made no comment.

*Participant 3*

**12.3.1.** Similar to the previous comment, participant 3 pointed out the label confusion.

**12.3.2.** Participant 3 suggested to write more detailed footnotes. In the footnote, it is stated that the value of sinα is named as o. According to participant 3, it must also be written that "o" is in the algebra window.

*Participant 4*

**12.4.1.** Participant 4 requested to label a ray.

*Participant 5*

**12.5.1.** Participant 5 too suggested to change the interval of angle sliders.

**12.5.2.** Participant 5 too got confusion about the label of points.

**12.5.3.** Participant 5 too requested to label a ray.

**12.5.4.** Participant 5 pointed out that what should be done to make the trigonometric ratios defined should be written.

**12.5.5.** In this worksheet, the participants created $\frac{\cos(\alpha) = \text{number}}{\sin(\alpha) = \text{number}}$ and it was named as text 3. Participant 5 wrote that it was not clear that what number denotes exactly and asked one more explanation to be added to make it clear.

*Participant 6*

**12.6.1.** Participant 6 too provided feedback about the values which angle slider can take.

**12.6.2.** According to participant 6, the use of color function of GeoGebra is not extremely important. Participant 6 asked whether it is necessary to use the color function of GeoGebra or not.

**12.6.3.** Participant 6 commented on exponentiation sign. According to her exponentiation sign must be written more noticeably.

*Participant 7*

**12.7.1.** Participant 7 too gave feedback about the values which angle slider can take.

**Contextual based worksheet 13**

Two activities comprise worksheet 13. The main goal of the worksheet is to make the users understand the intended purpose of GeoGebra, to make them learn the attributes concerning with windows in GeoGebra very well and use function inspector feature of GeoGebra.

*Participant 1*

**13.1.1.** Participant 1 pointed out the confusion related to the label name of objects.

*Participant 2*

**13.2.1.** Participant 2 corrected a misspelling.

*Participant 3*

**13.3.1.** Participant 3requested not to construct a triangle randomly.Thecoordinate points of corner pointsmust be specified.

**13.3.2.** Participant 3 stated that the picture of *Preferences* icon given in the worksheet is wrong. Instead of the picture of *Preferences* icon, it was given the picture of *Objects* icon.Participant 3 corrected it.

**13.3.3.** In worksheet 13, the users are required to find point E whose coordinates are (0, 0). Participant 3 suggested to write which two elements of GeoGebra must be intersected to find point E.

**13.3.4.** Participant 3 put a suggestion about the order of instructions. The users are required to use SetConditionToShowObject[ <Object>, <Condition> ]. Command. In previous instructions the users are required to set the condition to show the objects without giving how to do it. Participant 3 suggested to give this command first.

**13.3.5.** Participant 3 claimed that she could not add the slider on the Graphics view although she did what the instructions told literally.

*Participant 4*

Participant 4 made no comment.

*Participant 5*

**13.5.1.** Participant 5 too suggested to describe which direction should be followed while constructing a polygon.

**13.5.1.** Participant 5 wrote that she could not complete the activity. The reason was that where to locate the triangle was not given.

**13.5.2.** Participant 5 corrected four misspellings in the worksheet.

**13.5.3.** Moreover, participant 5 reported feedback about the name of the folder which the GeoGebra files created by the users would be recorded. Although 13th worksheet is applied, the users are required to record their studies in the folder which is named as Worksheet 10. Participant 5 corrected it and made the name of the folder worksheet 13.

**13.5.4.** Participant 5 put a comment about coordinate names. Participant 5 pointed out that point A must have been created on y coordinate instead of x coordinate.

*Participant 6*

**13.6.1.** Participant 6 wrote that she wanted to learn why the use of color functions of and style functions of GeoGebra is necessary. According to participant 6 wrote that there was no need to use the color functions of and style functions of GeGebra.

*Participant 7*

**13.7.1.** Participant 7 stated that she could not create a slder because she did not remember how to create a slider. So, participant 7 could not continue to do the activity. Participant 7 suggested to remind the previous GeoGebra knowledge.

**Contextual based worksheet 14**

4 activities comprise worksheet 14. The main goal of the worksheet is to make the users able to use input to make calculations and use button feature of GeoGebra.

*Participant 1*

**14.1.1.** Participant 1 corrected one spelling mistake in the worksheet.

**14.1.2.** Participant 1 added the name of a point.

**14.1.3.** Participant 1 reported feedback about the name of the folder which the GeoGebra files created by the users will be recorded. Although 14th worksheet is applied, it is wanted from the users to record their studies into the folder which is named as Worksheet 10. Participant 5 corrected it and made the name of the folder Worksheet 14.

**14.1.4.** Participant 1 stated the confusion related to the labels of points.

*Participant 2*

Participant 2 made no comment.

*Participant 3*

**14.3.1.** Participant 3 too pointed out the confusion related to the point labels.

**14.3.2.** Participant 3 asked whether it is necessary to put a tick inside box near *Latex* or not.

**14.3.3.** One of the instructions require from the users to set a condition to show Point $F_2$ and the condition is that the value of slider must be greater than 90. Participant 3 wanted to learn why it must be done.

*Participant 4*

**14.4.1.** Participant 4 suggested not to use the color functions of GeoGebra.

*Participant 5*

**14.5.1.** Participant 5 stated the confusing related to the labeling of objects

**14.5.2.** Participant 5 corrected one misspelling in the worksheet.

**14.5.3.** To apply one of the instructions, the users are required to create a button which will work to show or hide the circle. Participant 5 wrote that it must be given which script is needed to do it.

**14.5.4.** While construction two circles, the users are required to keep the intersection area of circle d and circle e as small as it can but not to make it zero. According to participant 5 this instruction concerning with this must be given before constructing circle d and circle e.

**14.5.5.** Participant 5 suggested not to put the points on the board randomly.

**14.5.6.** Participant 5 reported that IsDefined[ <Object> ] command. Participant 5 wrote that the command did not work.

**14.5.7.** Participant 5 wrote that she could not change the background color of the board because of the fact that participant 5 could not remember how to do it.

*Participant 6*

**14.6.1.** Participant 6 requested to select the color.

*Participant 7*

**14.7.1.** Similar to the feedback provided by participant 6, participant 7 too requested to select color she desired.

**Contextual based worksheet 15**

This worksheet has only one activity. The main goal of this worksheet is to introduce functions included in the commands, the attributes related to object labels and also integer slider.

*Participant 1*

**15.1.1.** Participant 1's object labels was different from the worksheet. Participant 7 suggested that labels should match.

**15.1.2.** Participant 1 suggested not to use long sentences because long sentences make the activity less understandable. According to participant 1, the information intended to make to the users have must be summarized.

*Participant 2*

Participant 2 made no comment.

*Participant 3*

**15.3.1.** As Participant 1, Participant 3 too reported confusion between object labels while doing the activity when compared with the worksheet.

**15.3.2.** Instruction 1 of in activity 1 mistakenly refers to "angle radio button". The correct term should have been "integer radio button". Participant 3 made the necessary correction.

**15.3.3.** Within Instruction 18 of activity 1, the users hide point A, point B, point C, point D, point E and vector u. However, to apply instruction 8 of activity 1, the users hided point A and point B. Participant 3 provided a feedback about this mistake.

**15.3.4.** As Participant 1, participant 3 got confused too labels. Her labeling did not match with that of the worksheet.

*Participant 4*

**15.4.1.** As Participant 3, Participant 4 also reported the misused term "angle radio button".

*Participant 5*

**15.5.1.** As Participant 3, participant 5 also gave feedback about instruction 18 of activity 1.

**15.5.2.** Participant 5 wrote that she could not drag the slider because participant 5 did not know how to drag a slider. However, it was given how to do it in previous worksheets.

**15.5.3.** Instruction 40 of activity 1 requires the users to write "\;"to leave a blank. Participant 5 wrote that participant 5 could not write it.

**15.5.4.** Moreover, Instruction 40 of activity 1 aims to be able to use *Talic Letters*. Participant 5 is users to use italic letters to write the text. Participant 5 wrote that it must be given which words must be written in talic.

**15.5.5.** Participant 5 in worksheet 15, it was given the picture icon of *Graphics* but the picture was named as *Objects*. Participant 3 corrected it.

**15.5.5.** As participant 1 and participant 3, Participant 5 also made a comment about confusion concerning with the object labels.

*Participant 6*

**15.6.1.** As participant 3, participant 4 and participant 5, participant toogave feedback about the wrong type use of radio buttons.

**15.6.2.** Participant 6 gave a feedback about the use of pictures. Participant 6 wrote that the graph of sin(x) can be drawn without using a picture or constructing other objects.

*Participant 7*

**15.7.1.** As participant 3, participant 4, participant 5 and participant 6, participant 7 also reported on the misused term angle radio button.

**15.7.2.** As participant 3 and participant 5, participant 7 also gave feedback about instruction 18 of activity 1.

**15.7.3.** As participant 1 and participant 3, participant 7 also wrote down that her object labels did not match with the object label names on the worksheet.

**Contextual based worksheet 16**

Four activities compromise this worksheet. The main goal of this worksheet is to introduce the attributes related to the angle values and to make use of dynamically changing object colors.

*Participant 1*

**16.1.1.** She could not remember how to place the slider vertically.

**16.1.2.** Instruction 27 of activity 4 requires to sign in on the official website of GeoGebra. Participant 1 wrote that she could not sign it.

*Participant 2*

Participant 2 provided no feedback.

*Participant 3*

**16.3.1.** Instruction 2 of activity 1 mistakenly referred to function inspector icon as the eleventh icon of where the correct location is the tenth.

**16.3.2.** She stated learning skills regarding dynamic color changes was unnecessary.

*Participant 4*

**16.4.1.** As participant 1, she pointed out the wrong location description of function inspector.

**16.4.2.** Participant 4 pointed out the mistake made in instruction 7 of activity 2. The correct min value should have been -5 instead of -10 nd the max value should have been 5 instead of 10.

**16.4.3.** Participant 4 made a comment with regards to her object label names and object label names on the worksheet. She wrote that she tried to complete the activity ignoring this confusion but she was not able to do it.

*Participant 5*

**16.5.1.** As participant 1 and participant 4, participant 5 too pointed out the wrong location description of Function Inspector icon.

**16.5.2.** Participant 5 reported that she could not change the background color of Graphics window because she did not remember how to do it.

**16.5.3.** As participant 4, participant 5 too provided feedback about instruction 7 of activity 2. Participant 5 also suggested to delete the options inside of the Slider[ <Min>, <max>, <Increment>, <Speed>, <Width>, <Is angle>, <Horizontal>, <Animating>,< Random> ] command which are not used because it can cause confusion.

**16.5.4.** As participant 1, participant 5 too reported that she did not know how to place the slider vertically.

**16.5.5.** Participant 5 pointed out a mistake reference made in instruction 39 in activity 2. Participant 2 corrected it.

**16.5.6.** As participant 4, participant 5 reported the confusion related to the object label names. Because of this reason, participant 5 could not complete the activity.

**16.5.7.** Participant 5 suggested to change the footnote denotations otherwise they look like exponential numbers.

**16.5.8.** Instruction 26 of activity 3 requires the users to put "İç açıları Toplamı = [ ( n = n ) – 2 ] * 180° = α" on the graphics window. Participant 5 suggested to add how to find.

*Participant 6*

Participant 6 provided no feedback.

*Participant 7*

Participant 7 provided no feedback.

**Contextual based worksheet 17**

This worksheet includes 4 activities. The main goal of the worksheet is to teach how to export files as a word document, as a picture, to hide or show windows and to introduce the users with the attributes related to the creation of circles.

*Participant 1*

Participant 1 provided no feedback.

*Participant 2*

Participant 2 provided no feedback.

*Participant 3*

**17.3.1.** She pointed out that instruction 4 activity 1 had a mistake in label name. She corrected it.

*Participant 4*

**17.4.1.** As participant 3, she pointed out the same mistake done in instruction 4 activity 1.

*Participant 5*

**17.5.1.** Participant 5 corrected one misspelling.

*Participant 6*

Participant 6 made no comment.

*Participant 7*

**17.7.1.** She commented that color and style functions of GeoGebra was used over and over.

**Summary of worksheet feedbacks by category**

Feedbacks collected from first year pre-service mathematics teachers were grouped under three main categories: General Computer Literacy Knowledge, Errors and Mistakes in the Worksheets, and Mathematical Errors (see Table 6). General Computer Literacy Knowledge feedback categories were divided into two groups: Lack of Graphical User Interface (GUI) and Transfer of Knowledge Skills. Errors and Mistakes in the Worksheets feedback categories were divided into 7 groups: Wrong Term Use, Wrong Location Description, Spelling and Grammatical Errors, Confusing Directions, Incomplete Directions, Directions in Wrong Order and Directions Need Improves. Mathematical Error categories were divided into two groups, which are Incomplete Mathematical Information and Wrong Values.

The feedbacks that fall under Lack of GUI group under the heading "General Computer Literacy Knowledge" are the feedbacks that were resulted in lack of computer technology use by the first-year pre-service mathematics teachers. It was also detected that first-year pre-service mathematics teachers sometimes could not apply what they learned in previous worksheets to the new situations they encountered. So, feedbacks that fall under the Transfer of Knowledge Skills group under the heading "General Computer Knowledge" is provided by first-year pre-service mathematics teachers because they cannot use their previous knowledge.

Errors and mistakes were made unconsciously when writing worksheets. First-year pre-service mathematics teachers detected such errors and mistakes, and recommended correction of them or changing them as necessary. Sometimes wrong terms or concepts were used in labeling the icon pictures or describing a new term. Wrong Term Use feedbacks were provided for the wrong terms to be corrected. The location of the icons or terms was given wrongly in some activities. The feedbacks given to correct such kind of mistakes were grouped under Wrong Location Description. The worksheets also have some spelling mistakes which were gathered under the Spelling and Grammatical Errors group. The feedbacks provided to detect these spelling mistakes were brought into Spelling and Grammatical Mistakes. Developments recently made on GeoGebra after completing the worksheets caused confusion such as name differences, changes on commands, etc. The feedbacks given to indicate the confusion were grouped as Confusing Directions. According to first-year pre-service mathematics teachers some information should have been provided to understand the instructions completely. The feedbacks provided as such were put under the group of Incomplete Directions. Furthermore, some instructions were given in the wrong order. The feedback groups given to put them in the wrong order were named as Directions in the wrong order. The feedbacks provided for the instructions which need to be explained in more detailed way were brought under the group of Directions Need Improvement.

The last main group was created to show the feedbacks which exist due to errors concerning mathematical knowledge. Since GeoGebra tutorial lesson materials meet the MEB high school mathematics objectives, contextual based worksheets include the use of mathematical terms and mathematical signs. Some of the first year pre-service mathematics teachers suggested to add mathematical information to be used in the worksheets. Feedbacks provided to add more mathematical information fallö under Incomplete Mathematical Information. Moreover, there are mistakes which result in the wrong use of mathematical terms and mathematical values. The feedbacks which were given to correct the wrong use of numbers fell under the group of Wrong Mathematical Values.

Table 6
Feedback categories

| Feedback Type / Worksheet Number | General Computer Literacy Knowledge | | Errors and Mistakes in the worksheets | | | | | | | Mathematical Errors | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lack of GUI and text manipulation skill | Transfer of knowledge skills | Wrong term use | Wrong location description | Spelling and grammatical errors | Confusing directions | Incomplete directions | Directions in wrong order | Directions need improves | Incomplete mathematical information | Wrong values |
| Worksheet Number 1 | 1.1.4, 1.4.2, 1.5.1, 1.7.2. | 1.1.1, 1.6.1, 1.6.2, 1.7.1. | | | | 1.2.1, 1.3.1. | 1.4.1. | | | 1.1.2, 1.1.3. | |
| Worksheet Number 2 | 2.5.1, 2.7.1. | 2.1.1, 2.3.1, 2.4.2, 2.5.2. | 2.7.2. | 2.4.1. | 2.1.3. | | | | 2.1.2, | | |
| Worksheet Number 3 | 3.1.1. | 3.4.3, 3.6.1, 3.7.1. | | | | | | 3.4.1. | 3.4.2. | | |
| Worksheet Number 4 | 4.1.1, 4.2.1, 4.5.2, 4.6.1, 4.7.1, 4.7.2. | 4.2.1, 4.3.1, 4.6.2. | | | | | | | 4.1.2, 4.5.1. | | |
| Worksheet Number 5 | | | | | 5.1.1. | | 5.4.1, 5.5.1. | | | | |

Table 6
Feedback categories

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Worksheet Number 6 | 6.2.1, 6.3.2, 6.7.1, 6.7.2. | 6.1.1, 6.1.3, 6.2.2. | | 6.5.3. | 6.2.3, 6.3.4, 6.5.1, 6.5.2, 6.5.5, 6.5.7. | | | 6.1.2, 6.1.3, 6.3.1, 6.3.3, 6.4.1, 6.5.4, 6.5.6, 6.5.8. |
| Worksheet Number 7 | 7.5.3, | 7.5.7, 7.6.1. | | 7.5.5. | 7.2.1, 7.5.4. | 7.1.1, 7.1.2, 7.3.1, 7.5.1, 7.5.6. | 7.5.2. | 7.4.1 |
| Worksheet Number 8 | | 8.3.1, 8.3.2. | 8.5.4. | | | 8.5.5, | 8.5.2, 8.5.3. | 8.1.1, 8.4.1, 8.5.1, 8.6.1. |
| Worksheet Number 9 | 9.7.1. | 9.5.2. | | | 9.1.1, 9.3.1, 9.4.1, 9.5.3. | | 9.3.2. | 9.5.1. |
| Worksheet Number 10 | 10.7.1, 10.7.2, 10.7.3. | 10.1.1, 10.3.1, 10.5.1. | 10.3.2, 10.5.4, 10.5.5, 10.5.6. | | 10.5.2, 10.5.3. | | | |
| Worksheet Number 11 | 11.2.3. | 11.3.1. | 11.2.2, 11.3.2, 11.5.4. | | | 11.1.1, 11.4.1, 11.5.3. | 11.5.1, 11.5.2. | 11.2.1. |

Table 6
Feedback categories

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Worksheet Number 12 | 12.6.2, 12.6.3. | 12.1.3, 12.3.2, 12.5.4, 12.5.5, 12.6.1, 12.7.1. | | | 12.5.2, 12.1.2,12.3 .1. | | | 12.4.1, 12.5.3. | 12.1.1, 12.5.1. |
| Worksheet Number 13 | 13.6.1. | 13.3.3, 13.3.5, 13.7.1. | 13.3.2, 13.5.3, 13.5.4. | 13.2.1, 13.5.2, | 13.1.1. | 13.3.4 | | 13.3.1, 13.5.1, | |
| Worksheet Number 14 | 14.4.1, 14.6.1, 14.7.1. | 14.3.2, 14.3.3, 14.5.6, 14.5.7. | 14.1.3. | 14.1.1, 14.5.2. | 14.1.4, 14.3.1, 14.5.1. | 14.1.2, 14.5.3. | 14.5.4. | 14.5.5. | |
| Worksheet Number 15 | 15.6.2, 15.7.1, 15.7.2, 15.7.3. | 15.5.2, 15.5.3, 15.6.1. | 15.3.2, 15.3.3, 15.4.1, 15.5.1, 15.5.5. 15.7.1, | | 15.1.1, 15.1.2, 15.3.4. | 15.5.4. | | | |

Table 6
Feedback categories

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Worksheet Number 16 | 16.3.2. | 16.1.1, 16.1.2, 16.5.2, 16.5.4, 16.5.7, 16.5.8. | 16.3.1. 16.4.1, 16.5.1, 16.5.5. | | 16.4.3, 16.5.6. | 16.5.3. | 16.4.2. |
| Worksheet Number 17 | 17.7.1. | | | 17.5.1. | 17.3.1, 17.4.1, | | |

## Simple descriptive statistics on survey analysis

This part includes analysis of data which were gathered through the survey. The survey had a total of number of 63 questions on a 5 level Likert. Seven domains were assessed trough the survey (see p. 56). Descriptive statistics were used to analyze the data.

Table 7
Overall descriptive statistics of the worksheets

| Worksheets | N | Mean | Std Dev | Minimum | Maximum |
|---|---|---|---|---|---|
| W1 | 426 | 4.52 | 1.08 | 1.00 | 5.00 |
| W2 | 427 | 4.58 | .88 | 1.00 | 5.00 |
| W3 | 427 | **4.66** | .87 | 1.00 | 5.00 |
| W4 | 427 | 4.33 | .98 | 1.00 | 5.00 |
| W5 | 427 | 4.35 | .98 | 1.00 | 5.00 |
| W6 | 425 | 4.24 | .98 | 1.00 | 5.00 |
| W7 | 427 | 4.33 | 1.03 | 1.00 | 5.00 |
| W8 | 427 | 4.30 | 1.04 | 1.00 | 5.00 |
| W9 | 427 | 4.55 | .88 | 1.00 | 5.00 |
| W10 | 427 | 4.49 | .97 | 1.00 | 5.00 |
| W11 | 427 | 4.28 | **1.20** | 1.00 | 5.00 |
| W12 | 427 | **4.12** | 1.11 | 1.00 | 5.00 |
| W13 | 427 | **4.16** | 1.16 | 1.00 | 5.00 |
| W14 | 427 | 4.36 | 1.09 | 1.00 | 5.00 |

Table 7
Overall descriptive statistics of the worksheets

| | | | | | |
|---|---|---|---|---|---|
| W15 | 427 | 4.37 | .95 | 1.00 | 5.00 |
| W16 | 426 | 4.38 | 1.07 | 1.00 | 5.00 |
| W17 | 427 | 4.44 | 1.00 | 1.00 | 5.00 |

As can be see from table 7 the overall mean values for each worksheet received relatively high ratings. Worksheet 12 and 13 received the lowest mean score of 4.12 and 4.16 relatively (sd. 1.11 & 1.16). Worksheet 3 received the highest mean score of 4.66 (sd. 87). The range value between the highest and lowest worksheet was 0.54. Worksheets 2-6, 9-10, & 15 all had a standard deviation value less then 1. Indicating less variation among the participants opinion. Worksheet 11 had the greatest variation among the participants opinion (sd. 1.20).

Table 8
Detailed descriptive statistics of the survey part 1, survey part 2, survey part 3, and survey part 4 by worksheets

| Variable | N | P1 | sd | P2 | sd | P3 | sd | P4 | sd |
|---|---|---|---|---|---|---|---|---|---|
| Worksheet 1 | 140 | 4.40 | 1.20 | 4.63 | 0.90 | 4.60 | 1.06 | 4.78 | 0.44 |
| Worksheet 2 | 140 | 4.46 | 1.14 | 4.63 | 0.63 | 4.70 | 0.62 | 5.00 | 0.00 |
| Worksheet 3 | 140 | 4.38 | 1.20 | 4.84 | 0.38 | 4.85 | 0.50 | 5.00 | 0.00 |
| Worksheet 4 | 140 | 4.45 | 1.00 | 4.25 | 0.99 | 4.50 | 0.84 | 4.44 | 0.53 |
| Worksheet 5 | 140 | 4.44 | 0.97 | 4.39 | 0.88 | 4.37 | 0.99 | 3.89 | 0.78 |
| Worksheet 6 | 138 | 4.46 | 0.96 | 4.04 | 0.98 | 4.46 | 0.77 | 4.00 | 0.71 |
| Worksheet 7 | 140 | 4.30 | 1.20 | 4.55 | 0.69 | 4.34 | 1.03 | 3.78 | 0.83 |
| Worksheet 8 | 140 | 4.32 | 1.22 | 4.33 | 0.92 | 4.49 | 0.80 | 4.11 | 0.78 |

Table 8
Detailed descriptive statistics of the survey part 1, survey part 2, survey part 3, and survey part 4 by worksheets

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Worksheet 9 | 140 | 4.44 | 1.14 | 4.76 | 0.48 | 4.57 | 0.69 | 4.22 | 0.83 |
| Worksheet 10 | 140 | 4.31 | 1.19 | 4.72 | 0.64 | 4.73 | 0.65 | 4.22 | 0.83 |
| Worksheet 11 | 140 | 4.21 | 1.40 | 4.35 | 1.08 | 4.66 | 0.74 | 3.11 | 1.17 |
| Worksheet 12 | 140 | 4.24 | 1.18 | 4.24 | 0.89 | 4.11 | 1.18 | 3.78 | 0.83 |
| Worksheet 13 | 140 | 4.20 | 1.24 | 4.19 | 1.01 | 4.16 | 1.31 | 4.22 | 0.44 |
| Worksheet 14 | 140 | 4.24 | 1.27 | 4.50 | 0.93 | 4.50 | 0.98 | 4.22 | 0.67 |
| Worksheet 15 | 140 | 4.36 | 1.13 | 4.42 | 0.78 | 4.57 | 0.72 | 4.22 | 0.67 |
| Worksheet 16 | 140 | 4.32 | 1.29 | 4.45 | 0.80 | 4.56 | 0.96 | 4.22 | 0.67 |
| Worksheet 17 | 140 | 4.36 | 1.24 | 4.45 | 0.82 | 4.74 | 0.56 | 4.67 | 0.50 |

Table 9
Detailed descriptive statistics of the survey part 5, survey part 6, and survey part 7 by worksheets

| Variable | P5 | sd | P6 | sd | P7 | sd |
|---|---|---|---|---|---|---|
| Worksheet 1 | 3.86 | 1.95 | 3.75 | 1.28 | 4.50 | 1.41 |
| Worksheet 2 | 4.14 | 1.46 | 4.38 | 1.41 | 4.38 | 1.41 |
| Worksheet 3 | 3.86 | 1.95 | 4.25 | 1.49 | 4.38 | 1.41 |
| Worksheet 4 | 3.14 | 1.21 | 4.00 | 0.53 | 3.38 | 1.06 |
| Worksheet 5 | 3.86 | 1.95 | 4.13 | 1.46 | 2.88 | 0.83 |
| Worksheet 6 | 4.29 | 1.50 | 3.88 | 1.25 | 3.00 | 0.93 |
| Worksheet 7 | 3.57 | 1.40 | 3.13 | 1.36 | 2.75 | 0.89 |
| Worksheet 8 | 3.14 | 1.46 | 3.63 | 1.19 | 3.50 | 1.07 |
| Worksheet 9 | 3.71 | 1.89 | 4.25 | 1.39 | 3.38 | 1.06 |
| Worksheet 10 | 3.43 | 0.98 | 3.38 | 1.60 | 2.75 | 0.89 |

Table 9
Detailed descriptive statistics of the survey part 5, survey part 6, and survey part 7 by worksheets

| | | | | | | |
|---|---|---|---|---|---|---|
| Worksheet 11 | 3.57 | 1.27 | 3.75 | 0.89 | 2.63 | 1.41 |
| Worksheet 12 | 1.86 | 0.69 | 2.75 | 1.28 | 3.25 | 0.71 |
| Worksheet 13 | 3.71 | 1.89 | 3.88 | 1.46 | 3.50 | 1.07 |
| Worksheet 14 | 3.14 | 1.57 | 3.75 | 1.04 | 3.75 | 1.16 |
| Worksheet 15 | 3.14 | 1.68 | 3.88 | 1.25 | 3.38 | 1.06 |
| Worksheet 16 | 3.86 | 1.95 | 4.13 | 1.46 | 3.00 | 1.07 |
| Worksheet 17 | 3.43 | 1.72 | 4.00 | 1.41 | 3.38 | 1.06 |

In order to understand the variations show in table 8 and table 9, the data were analyzed with respect to the seven survey parts. Table 8 and Table 9 show the mean score and associated standard deviation values for each worksheet by survey parts. For part 1 Worksheets 9 received the highest mean score of 4.91 (sd. 0.35) and worksheet 12 received the lowest mean score of 4.11 (sd. 1.09). For part2 worksheets 3 received the highest mean score of 4.75 (sd. 0.46) and worksheet 6 received the lowest mean score of 3.90 (sd. 98). For part 3 worksheets 10 received the highest mean score of 4.91 (sd. 0.37) and worksheet 14 received the lowest mean score of 4.63 (sd. 0.89).

For part 4 worksheet 1 received the highest mean score of 4.90 (sd. 0.30) and worksheet 13 received the lowest mean score of 4.24 (sd. 1.09). For part 5 worksheets 5 received the highest mean score of 4.12 (sd. 1.27) and worksheet 10 received the lowest mean score of 3.63 (sd. 1.38). For part 6 Worksheets 2 received the highest mean score of 4.39 (sd. 1.19) and worksheet 12 received the lowest mean score of 3.59 (sd. 1.41). For part 7 worksheets 3 received the highest mean score of

4.84 (sd. 0.68) and worksheet 6 received the lowest mean score of 3.98 (sd. 1.04). Worksheet 3 was rated two times with the highest mean score. Whereas, worksheet 12 received two times the lowest mean score.

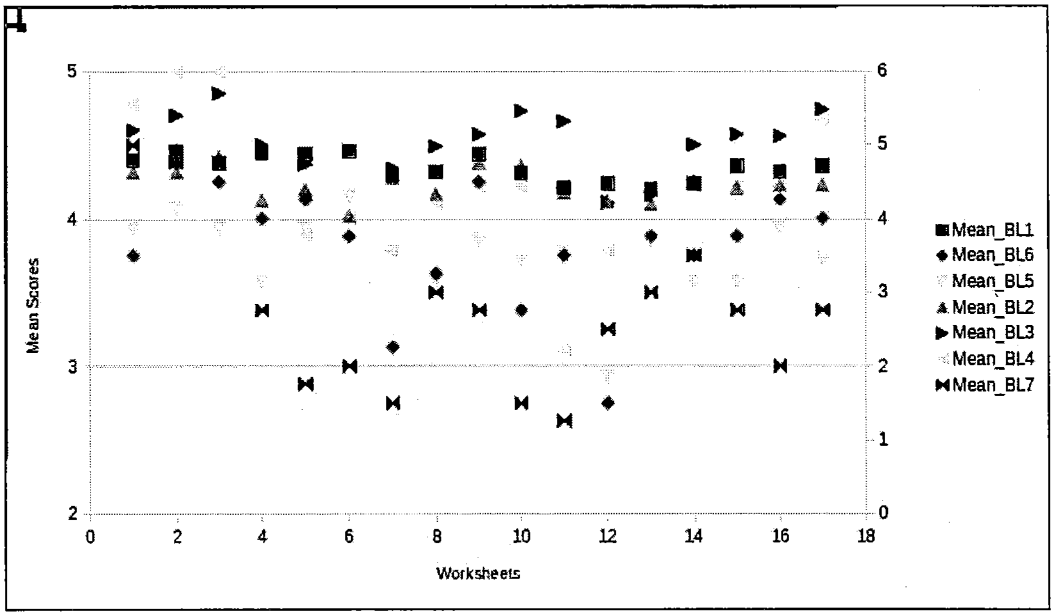


Figure 9. Graphical representation of the 7 part survey mean scores by worksheets

Figure 9 indicated that part 5 consistently received a low mean score for all worksheets. The questions on the survey regarding part 5 were about the use of language. Whereas the physical properties of the worksheets (part 3) were rated consistent and received a high mean score. Part 1 consisted of questions regarding the perceived learning effect. The data indicates that the worksheets seamed to have a higher perceived learning effect initially (Worksheet 1-Worksheet 3). For worksheets 4 to 8 the perceived learning effect was slightly lower than the initial first three worksheets, but still high and had a constant comparable mean score value of about 4.40. Worksheet 12 was received as the least effective as far as learning effect is concerned. It should be noted that part 5 and part 6 also received the lowest mean score for the same worksheet. Part 5 was about language and part 6 about the perceived correctness of logical sequence of instructions. The descriptions or the locigal setup of instruction sequence might have influenced a low score for worksheet 12. This fact is also consistent with the data shown in table 7.

Part 1, part 3 and part 4 were scored consistently high. Part 3 which was about the physical properties of the worksheets was rated most often as number 1, followed by part 4 which is about information accuracy. The pre-service teachers felt that the worksheets provided effective learning opportunities (part 1).

For worksheet 8, the pre-service teachers scored part 2 (worksheet objectives) and part 7 (relation to MEB curriculum) with the lowest mean score value. Two activities made up worksheet 8. The initial activity was traditional mathematical topic on the concept of center of mass. The second activity tight this concept to a real-life example. Informal interviews with the pre-service teachers revealed that they found the second activity unnecessary and would not use such an example while teaching the concept of center of mass.

Table 10
Detailed descriptive statistics of the 4 pre-service teachers by worksheets

| Worksheet | Participant 1 | Participant 2 | Participant 3 | Participant 4 |
|---|---|---|---|---|
| Worksheet 1 | 4,46 | 3,64 | 4,79 | 4,74 |
| Worksheet 2 | 4,57 | 3,85 | 4,80 | 4,59 |
| Worksheet 3 | 4,56 | 4,38 | 4,80 | 4,59 |
| Worksheet 4 | 3,85 | 4,41 | 4,87 | 4,56 |
| Worksheet 5 | 3,84 | 4,11 | 4,93 | 4,70 |
| Worksheet 6 | 3,93 | 3,71 | 4,80 | 4,77 |
| Worksheet 7 | 3,49 | 4,18 | 4,77 | 4,77 |

Table 10
Detailed descriptive statistics of the 4 pre-service teachers by worksheets

| | | | | |
|---|---|---|---|---|
| Worksheet 8 | 3,79 | 4,51 | 4,79 | 4,77 |
| Worksheet 9 | 4,13 | 4,46 | 4,79 | 4,84 |
| Worksheet 10 | 3,70 | 4,51 | 4,84 | 4,77 |
| Worksheet 11 | 3,26 | 4,61 | 4,79 | 4,61 |
| Worksheet 12 | 3,31 | 4,52 | 4,82 | 4,74 |
| Worksheet 13 | 3,95 | 3,57 | 3,98 | 4,98 |
| Worksheet 14 | 3,98 | 4,15 | 4,00 | 4,82 |
| Worksheet 15 | 3,84 | 4,46 | 4,92 | 4,87 |
| Worksheet 16 | 3,92 | 4,44 | 4,43 | 4,75 |
| Worksheet 17 | 3,93 | 4,41 | 4,74 | 4,77 |

Table 11
Detailed descriptive statistics of the 4 pre-service teachers by worksheets

| Worksheet | Participant 5 | Participant 6 | Participant 7 |
|---|---|---|---|
| Worksheet 1 | 4,57 | 4,74 | 4,69 |
| Worksheet 2 | 4,57 | 4,87 | 4,79 |
| Worksheet 3 | 4,62 | 4,80 | 4,87 |
| Worksheet 4 | 4,66 | 4,56 | 3,41 |
| Worksheet 5 | 4,69 | 4,13 | 4,05 |
| Worksheet 6 | 4,61 | 3,98 | 3,85 |
| Worksheet 7 | 4,56 | 4,30 | 4,28 |
| Worksheet 8 | 4,62 | 3,75 | 3,90 |
| Worksheet 9 | 4,62 | 4,49 | 4,54 |
| Worksheet 10 | 4,70 | 4,34 | 4,59 |

Table 11

Detailed descriptive statistics of the 4 pre-service teachers by worksheets

| | | | |
|---|---|---|---|
| Worksheet 11 | 4,64 | 4,31 | 3,77 |
| Worksheet 12 | 4,38 | 3,54 | 3,52 |
| Worksheet 13 | 4,64 | 4,43 | 3,57 |
| Worksheet 14 | 4,64 | 4,56 | 4,36 |
| Worksheet 15 | 4,64 | 4,08 | 3,82 |
| Worksheet 16 | 4,62 | 4,26 | 4,23 |
| Worksheet 17 | 4,66 | 4,31 | 4,23 |

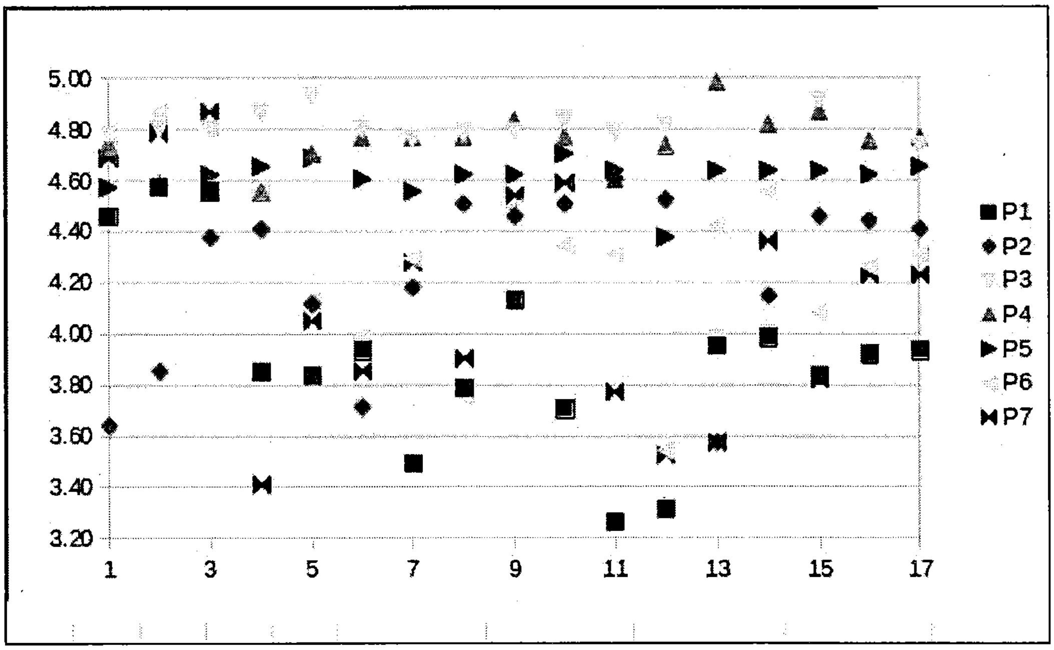


Figure 10. Graphical view of the mean scores of the seven pre-service teachers by worksheets

Since the data pool was very limited to only seven pre-service teachers, outliers could affect drastically the dataset. Table 10, table 11 and the accompanying figure 10 show the mean score distribution by pre-service teacher for each worksheet. The results indicate two dimensions to the data. The first dimension is related to the degree of consensus among the participants. The second dimension is related to worksheets perceived instructional value.

There seems to be a high degree of consensus among the pre-service teachers for worksheet 1- 3, 7 – 10, 14 – 17. Moreover, pre-service teachers that rated the worksheets initially relatively high tended to do so for all worksheets (Participant 3, Participant 4, Participant 5 and Participant 2). Participant Participant 1 showed a consistent decrease in worksheet ratings after the third worksheet. However, she was theamong those that had provided the least amount of written feedback. This holds true for Participant 2, too. Participant 5, Participant 3, Participant 7, and Participant 4 were the ones that provided the most written feedback, suggestions and corrections on the worksheets.

# CHAPTER 5: DISCUSSION

## Introduction

This research based study intented to develop contextual based instructional GeoGebra worksheets to make high school mathematics teachers learn how to use GeoGebra effectively and appropriately in their classrooms. 17 contextual based instructional GeoGebra worksheets were produced by researchers and they were applied by first year pre-service mathematics teachers to evaluate the effectiveness and accuracy of them. Considering feedbacks given during data collection process by first year pre-serive mathematics teachers and observation results of the author, the worksheets will be redeveloped. In this chapter, generally the results and findings of the data collection process was discussed. Following sections, *Overview of the Study, Major findings, Implication for Practice, Implication for Further Research and Limitations* are contained in this chapter to give information about what this section covers.

## Overview of the study

This research study intended to develop instructional materials for both in-service and pre-service teachers for learning GeoGebra. The contextual based instructional materials aimed to meet both Turkish high school mathematics curriculum and GeoGebra learning objectives. Hence, the resulting instructional materials were referred to contextual instructional materials to distingush them from a purly approach of GeoGebra software based learning and teaching materials.

The development procedure of this study went through four main phases. The identification of GeoGebra learning objective, matching procedure between Geogebra learning objective and MEB objective, worksheet development (initially 23, after review 17 were used), application of worksheets to first year pre-service mathematics teachers.

The seven first year pre-service mathematics teachers who were enrolled in Bilkent University went and did each worksheet and provided written feedback to evaluate seven domains of the developed worksheets. These were cognitive and psychomotor, affective domain, accuracy of information, physical and esthetic design, accuracy of language, logic of instructions, MEB high school mathematics relevancy. As a result, the responses on the survey and first year pre-service mathematics teachers' written feedback provided the data for the reiteration and revision of the 17 worksheets.

## Major findings

One fundamental assumption made while developing the instructional materials was with respect to intrinsic motivation. Intrinsic motivation and its possible effects towards directing one's own learning comes from Bandura's self-efficacy theory (1986). The instructional materials were developed within the realm of the MEB high-school mathematics curriculum. Hoping that the pre-service teachers would "see" the value of learning and using GeoGebra, rather than taking a pure software teaching approach.

One major find of this research was that the pre-service teachers involved in this study made consistent remarks regarding "unnecessary" instructions. Examples such as "sin(x) can be drawn without using a picture **(15.6.2)**", "why to position the slider vertical **(16.5.4.)**" are a few among the many ones reported in chapter 4. A further evidence about intrinsic motivation might be the fact that none of the pre-service teachers provided any evidence that they referred to previous worksheets. This is evident, especially when they encountered a problem. They just stated the fact that they could not remember it without trying to or looking for a solution to the problem. In some cases, they completely drop or refused to complete the activity (e.g. Participant 3, Participant 6, and Participant 7). Creating cross-references between worksheets could perhaps be an incentive for future learners to go and look up previous worksheets.

Although, initially a good idea of trying to create contextual based instructional materials, especially towards self-based learning, it seems that some other type of measure and incentive needs to be considered for upcoming instructional learning materials.

Besides intrinsic motivation, pre-service teachers' general computer literacy seemed to have played an important role for some of their struggle. It is evident that some of the participants had difficulties just because they had a lack of knowledge of basic modern computing skills. For example, the fact the one needs to first select an object before trying to manipulate it, enabling/disabling and/or rearranging windows, parent window-child window relationship, and tab navigation to name a few (e.g., **3.7.1).** The worksheets that had been developed had no direct objectives and instructions regarding the basic operations of a modern computer software. It seems that new materials should include such basic activities initially, even if it is optional.

A spiral approach was used whenever possible to reinforce learned skills. Many objectives were required to be completed several times in different worksheets. This approach seemed to have created some problems with a few of the participants (e.g., Participant 6, Participant 7 [**12.6.2.-13.6.1, 10.7.2**]). Instead of having this type of directions in the main instruction item, one solution would be to create a sub-instruction that is optional to follow.

The worksheets were designed to be progressively more complex and task demanding while the instructions were becoming less detailed. When encountering these type of activities, the participants requested more detailed instructions by stating that they had difficulties completing the activity. Figure 9 clearly depicts that some of the pre-service teachers had problems with Worksheet 5 to Worksheet13. A solution to this problem might be by actually creating worksheets based on difficulty levels rather than a holistic approach of GeoGebra learning objectives. For example the worksheets could be developed as basic level, intermediate level and advanced level.

Basic level worksheets would only utilize the graphics window and icon based object creation (select, point and click). None of the menu driven and algebra window based object manipulations of objects would be a part of this level. The intermediate level would target skills such as the relationship between algebra and graphics window objects, static object attribute manipulation through the concept of parent-child window and an introduction to the "slider" object. The slider would serve as an anchor for the concept of variables in computer programming. Advanced level would include the manipulation through command line input, the concept of variables and types of variables, and library functions, dynamic (programmatic) object and attribute manipulation. Now it should be pointed out that that this suggestion is only restricted to the domain of geometry. GeoGbra provides many more features, such as computer algebra system (CAS), statistics, spreadsheet functionality and 3D object creation and manipulations.

## Implications for practice and further research

This research was conducted with only seven first year pre-service teachers. Clearly a low and restricting number to generalize the results obtained in this study. However, one domain of the results seemed to indicate that the pre-service teachers faced some basic problems while trying to follow and learn GeoGebra. Their written statements provided some evidence of lack of knowledge regrading general computer literacy. Similar findings were reported elsewhere. For example, Preiner (2008), a researcher at the University of Salzburg, where GeoGebra was conceived, reached a similar conclusion. She conducted workshops specifically for in-service mathematics teachers and reported her findings. The common impediments she encountered frequently while trying to teach GeoGebra was with respect to, text processing, file handling, and picture file handling. Based on this fact, a good starting point might be to stage a study that would try to reveal and compare the learning difficulties of novice and expert mathematics teachers as far as general computer literacy is concerned with respect to GeoGebra learning. The results of these types of studies might provide valuable information towards the content and off course, theextend of content needed to be covered in instructional materials for successful GeoGebra learning.

It should be pointed out that this study did not deal directly assessing the effect of learning GeoGebra. These instructional materials prepared in this study should be scientifically evaluated regarding its effectiveness of self-based learning of GeoGebra. In doing so, the short comings of this study can be overcome.

Learning objectives related to GeoGebra were created as a part of this research which framed the content of the worksheets. In a similar manner, using the objectives related to GeoGebra learning should be used to develop a valid and reliable assessment instrument. Such a standardized test could be used in several important ways. For example, evaluating the effectiveness of a teaching and learning workshops, differentiating participants' knowledge levels and providing accordingly instructional materials and/or redesigning these materials. Moreover, results of a standardized test would also contribute to a database about common impediments GeoGebra learners face.

Finally, some tangential evidence regarding the possible intention of integrating dynamic geometry software as a teaching and learning tool exists base on the formal observations conducted and informal talks during the research. To be a bit more specific, 10 hours long classroom time was allocated for completing the worksheets. The researcher was present at all times during these class hours. She received only minor questions during these classroom sessions. Also, the pre-service teachers had ample spare time to work on the worksheets at off-hours. Moreover, none of the pre-service teachers reported to discover "new" feature or asked for information beyond those provided by the worksheets. Moreover, later in the semester, all pre-service teachers were required to do practice teaching at schools as a part of their formal teacher training education. None of them tried to use GeoGebra. These actually comes as no surprise. Because "simply training teachers to use appropriate tools in workshops doesn't guarantee that they are going to use the same technology effectively in their classrooms (Mously et al., 2003, p.421).

Hence, studies that have their worksheet context around good practice models of integration of technology in mathematics education with instructional learning GeoGebra objectives need to be explored.

## Limitation

There are a number of limitations which should be considered in this research. The researcher had a limited access to voluntary participants. Secondly, none of the participants were practicing mathematics teachers. So their written feedbacks and survey responses should be interpreted in this manner. The lack of a second iteration for the revised worksheets was due to time constraint the research faced.

GeoGebra is a dynamic mathematics software which improves fast. However instructional design method requires time and great effort. Until completing the study, new features has been added to GeoGebra. Mathematics teachers will need new produced GeoGebra tutorial materials to learn how to use these features and integrate these features to their teachings.

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# APPENDICES

## APPENDIX A: MEB high school mathematics curriculum objectives

| | | |
|---|---|---|
| 9.4. Üçgenler | 9.4.1. Üçgenlerin Eşliği | 9.4.1.1. Bir üçgenin iç açılarının ölçüleri toplamının 180°, dış açılarının ölçüleri toplamının 360° olduğunu gösterir. |
| | | 9.4.1.2. İki üçgenin eşliğini açıklar, iki üçgenin eş olması için gerekli olan asgari koşulları belirler. |
| | | 9.4.1.3. Bir üçgende daha uzun olan kenarın karşısındaki açının ölçüsünün daha büyük olduğunu gösterir |
| | | 9.4.1.4. Uzunlukları verilen üç doğru parçasının hangi durumlarda üçgen oluşturduğunu belirler |
| | 9.4.2. Üçgenlerin Benzerliği | 9.4.2.1. Bir üçgenin bir kenarına paralel olarak çizilen bir doğru diğer iki kenarı kestiğinde bu doğrunun üçgenin kenarlarını orantılı doğru parçalarına ayırdığını (temel orantı teoremi) ve bunun karşıtının da doğru olduğunu gösterir. |
| | | 9.4.2.2. İki üçgenin benzerliğini açıklar, iki üçgenin benzer olması için gerekli olan asgari koşulları belirler. |
| | | 9.4.2.3. Üçgenlerin benzerliğini modelleme ve problem çözmede kullanır. |
| | 9.4.3. Üçgenin Yardımcı Elemanları | 9.4.3.1. Bir açının açıortayını çizer ve özelliklerini açıklar. |
| | | 9.4.3.2. Üçgenin iç ve dış açıortaylarının özelliklerini gösterir. |
| | | 9.4.3.3. Üçgenin kenarortaylarının bir noktada kesiştiğini gösterir ve kenarortayla ilgili özellikleri açıklar. |
| | | 9.4.3.4. Üçgenin kenar orta dikmelerinin bir noktada kesiştiğini gösterir. |
| | | 9.4.3.5. Üçgenin yüksekliklerinin bir noktada kesiştiğini gösterir ve üçgenin çeşidine göre bu noktanın konumunu belirler. |

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| | 9.4.4. Dik Üçgen ve Trigonometri | 9.4.4.1. Dik üçgende Pisagor teoremini ispatlar ve uygulamalar yapar. |
| | | 9.4.4.2. Dik üçgende dar açıların trigonometrik oranlarını tanımlar ve uygulamalar yapar. |
| | | 9.4.4.3. Birim çemberi tanımlar ve trigonometrik oranları birim çember üzerindeki noktanın koordinatlarıyla ilişkilendirir. |
| | | 9.4.4.4. Üçgende kosinüs teoremini ispatlar ve uygulamalar yapar. |
| | 9.4.5. Üçgenin Alanı | 9.4.5.1. Üçgenin alanını veren bağıntıları oluşturur ve uygulamalar yapar. |
| | | 9.4.5.2. Üçgende sinüs teoremini ispatlar ve uygulamalar yapar. |
| 9.5. Vektörler | 9.5.1. Vektör Kavramı ve Vektörlerle İşlemler | 9.5.1.1. Vektör kavramını açıklar. |
| 10.4. Analitik Geometri | 10.4.1. Doğrunun Analitik İncelenmesi | 10.4.1.1. Analitik düzlemde iki nokta arasındaki uzaklığı veren bağıntıyı oluşturur ve uygulamalar yapar. |
| | | 10.4.1.2. Bir doğru parçasını belli bir oranda (içten veya dıştan) bölen noktanın koordinatlarını hesaplar. |
| | | 10.4.1.3. Analitik düzlemde doğru denklemini oluşturur ve denklemi verilen iki doğrunun birbirine göre durumlarını inceler. |
| | | 10.4.1.4. Bir noktanın bir doğruya uzaklığını açıklar ve uygulamalar yapar. |
| 10.5. Dörtgenler ve Çokgenler | 10.5.1. Dörtgenler ve Özellikleri | 10.5.1.1. Dörtgenin temel elemanlarını ve özelliklerini açıklar. |
| | 10.5.2.Özel Dörtgenler | 10.5.2.1.Yamuk, paralelkenar, eşkenar dörtgen, dikdörtgen, kare ve deltoid ile ilgili açı, kenar ve köşegen özelliklerini açıklar |
| | | 10.5.2.2. Yamuk, paralelkenar, eşkenar dörtgen, dikdörtgen, kare ve deltoidin alan bağıntılarını oluşturur. |

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| | | 10.5.2.3. Dörtgenlerin alan bağıntılarını modelleme ve problem çözmede kullanır. |
| | 10.5.3. Çokgenler | 10.5.3.1. Çokgenleri açıklar, iç ve dış açılarının ölçülerini hesaplar. |
| 10.8. Çember ve Daire | 10.8.1. Çemberin Temel Elemanları | 10.8.1.1.Çemberlerde teğet, kiriş, çap ve yay kavramlarını açıklar. |
| | | 10.8.1.2.Çemberde kirişin özelliklerini gösterir. |
| | 10.8.2. Çemberde Açılar | 10.8.2.1. Bir çemberde merkez, çevre, iç, dış ve teğet-kiriş açıları açıklar; bu açıların ölçüleri ile gördükleri yayların ölçülerini ilişkilendirir. |
| | 10.8.3. Çemberde Teğet | 10.8.3.1. Çemberde teğetin özelliklerini gösterir. |
| | 10.8.4. Dairenin Çevresi ve Alanı | 10.8.4.1. Dairenin çevresini ve alanını veren bağıntılar oluşturur ve uygulamalar yapar. |
| 11.4. Trigonometri | 11.4.1. Yönlü Açılar | 11.4.1.1. Yönlü açıyı açıklar, açı ölçü birimlerinden derece ile radyanı ilişkilendirir. |
| | 11.4.2. Trigonometrik Fonksiyonlar | 11.4.2.1. Trigonometrik fonksiyonları birim çember yardımıyla oluşturur ve grafiklerini çizer. |
| | | 11.4.2.2. Tanjant, sinüs ve kosinüs fonksiyonlarının ters fonksiyonlarını oluşturur. |
| | 11.4.3. İki Açının Ölçüleri Toplamının ve Farkının Trigonometrik Değeri | 11.4.3.1. İki açının ölçüleri toplamının ve farkının trigonometrik değerlerine ait formülleri bulur. |
| | 11.4.4. Trigonometrik Denklemler | 11.4.4.1. Trigonometrik denklemlerin çözüm kümelerini bulur. |
| | 11.7.1. Analitik Düzlemde Temel Dönüşümler | 11.7.1.1. Analitik düzlemde koordinatları verilen bir noktanın öteleme, dönme ve yansıma dönüşümleri altındaki görüntüsünün koordinatlarını bulur. |

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| | 11.7.2. Öteleme, Yansıma, Dönme ve Bunların Bileşkelerini İçeren Uygulamalar | 11.7.2.1. Öteleme, dönme, yansıma ve bunların bileşkelerini modelleme ve problem çözmede kullanır. |
| 11.4. Ölçme | 11.4.1. Bir nesnenin belli bir oranda büyütülmüş ya da küçültülmüş bir çizimini kullanarak bir mesafe, bir nesnenin çevre uzunluğu, alanı veya hacmi hakkında çıkarımlarda bulunur. | |
| 12.3. Analitik Geometri | 12.3.1. Çemberin Analitik İncelenmesi | 12.3.1.1. Merkezi ve yarıçapı verilen çemberin denklemini oluşturur. |
| | | 12.3.1.2. Denklemleri verilen doğru ile çemberin birbirine göre durumlarını inceler. |
| | | 12.3.1.3. Çember üzerindeki bir noktadan çembere çizilen teğet ve normal denklemlerini oluşturur. |
| | 12.3.2. Elips, Hiperbol ve Parabolün Analitik İncelenmesi | 12.3.2.1. Parabol, elips ve hiperbolü tanımlar, standart denklemlerini elde eder ve uygulamalar yapar. |
| 12.4. Vektörler | 12.4.1. Standart Birim Vektörler ve İç Çarpım | 12.4.1.1. Standart birim vektörleri tanımlayarak bir vektörü standart birim vektörlerin lineer bileşimi şeklinde yazar. |
| | | 12.4.1.2. İki vektörün iç çarpımını açıklar ve iki vektör arasındaki açıyı hesaplar. |
| | | 12.4.1.3. Bir vektörün başka bir vektör üzerine dik izdüşümünü bulur. |

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|---|---|---|
| | 12.4.2. Bir Doğrunun Vektörel Denklemi | |
| | 12.4.3. Vektörlerle ilgili Uygulamalar | 12.4.3.1. Vektörel, sentetik ve analitik yaklaşımları problem çözmede kullanır. |
| 12.7. Uzay Geometri yaklaşımları | 12.7.1. Uzayda Doğru ve Düzlem | 12.7.1.1. Uzayda bir düzlemi belirleyen durumları inceler. |
| | | 12.7.1.2. Uzayda iki doğru; iki düzlem; bir düzlem ve bir doğrunun birbirlerine göre durumlarını belirler ve uygulamalar yapar. |
| | | 12.7.1.3. Uzayda iki düzlem arasındaki açıyı belirler. |
| | | 12.7.1.4. Bir şeklin bir düzlem üzerindeki izdüşümünü belirler ve uygulamalar yapar. |
| 12.3.Ölçme | 12.3.1. Dik üçgenleri gerçek/gerçekçi hayat problemlerini çözmede kullanır. | |
| | 12.3.2. Üçgenlerin benzerliğini, gerçek/gerçekçi hayat durumlarını modellemede ve problem çözmede kullanır. | |
| 12.4. Trigonometri ve Uygulamaları | 12.4.1. Yönlü açıyı açıklar, açı ölçü birimlerinden derece ile radyanı ilişkilendirir. | |

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|---|---|---|
| | 12.4.2. Trigonometrik fonksiyonları birim çember yardımıyla oluşturur ve grafiklerini çizer. | |
| | 12.4.3. Trigonometrik fonksiyonları gerçek / gerçekçi hayat durumlarını modellemede ve problem çözmede kullanır. | |

# APPENDIX B: GeoGebra Training objectives

| | Çalışma Kâğıdı 1 | Çalışma Kâğıdı 2 | Çalışma Kâğıdı 3 | Çalışma Kâğıdı 4 | Çalışma Kâğıdı 5 | Çalışma Kâğıdı 6 | Çalışma Kâğıdı 7 | Çalışma Kâğıdı 8 | Çalışma Kâğıdı 9 | Çalışma Kâğıdı 10 | Çalışma Kâğıdı 11 | Çalışma Kâğıdı 12 | Çalışma Kâğıdı 13 | Çalışma Kâğıdı 14 | Çalışma Kâğıdı 15 | Çalışma Kâğıdı 16 | Çalışma Kâğıdı 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1. GeoGebra' yı Geometri dersinde kullanmanın önemini fark eder.** | | | | | | | | | | | | X | O | O | O | O | O |
| **2. GeoGebra' yı öğrenmek için merak duygusu geliştirir ve GeoGebra kullanmaya karşı ilgisi artar.** | | | | | | | | | | | | X | O | O | O | O | O |
| **3. GeoGebra' nın ne tür amaçları karşılamak amacı ile geliştirilen bir yazılım olduğunu açıklar.** | | | | | | | | | | | | | X | O | O | O | O |
| **4. GeoGebra dosyalarının uzantısının ggb uzantılı dosyalar olduğunu tanılar.** | | | | | | | | | | | | X | O | O | O | O | O |
| **5. GeoGebra'nın özelliklerini geometri konuları ile nasıl ilişkilendireceğini ilişkilendirerek açıklar.** | | | | | | | | | | | | | X | O | O | O | O |
| **6. GeoGebra'yı kullanarak gerçek hayat ile ilgili problemler modeller ve bu problemleri çözer.** | | | | | | | | X | O | O | O | O | O | O | O | O | O |
| **7. GeoGebra' nın geometri dersini anlatmak amacı ile hangi özelliklerinden nasıl yararlanması gerektiği konusuna dair doğru tahminlerde bulunur.** | | | | | | | | | | | | | X | O | O | O | O |
| **8. Kullanıcı ara birimlerinin özeliklerini bilir ve kullanıcı ara birimlerini etkin bir biçimde kullanır.** | | | | | | | | | | | | X | O | O | O | O | O |
| Cebir Penceresi 'nin nerede yer aldığını bilir ve kullanım amacına yönelik çalışmalar yapar. | | | | | | | | | | | | | X | O | O | O | O |
| Grafik Penceresi' nin nerede yer aldığını bilir ve kullanım amacına yönelik çalışmalar yapar. | | | | | | | | | | | | | X | O | O | O | O |
| Grafik 2 Penceresi' nin nerede yer aldığını bilir ve kullanım amacına yönelik çalışmalar yapar. | | | | | | | | | | | | | | | | X | O |
| Hesap Çizelgesi Görünümü Penceresi' nin nerede yer aldığını bilir ve kullanım amacına yönelik çalışmalar yapar. | | | | | | | | | | | | X | O | O | O | O | O |
| Aynı GeoGebra dosyası içinde ikinci bir pencereyi açmak için Dosya-Yeni Pencere adımlarını sırasıyla takip eder. | | | | | | | | | X | O | O | O | O | O | O | O | O |

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| **9. Girdi birimlerinin özelliklerini bilir ve girdi birimlerini etkin bir biçimde kullanır.** | | | | | | | | | | | | | | | | | |
| Menü Çubuğu' nun nerede yer aldığını bilir ve Menü Çubuğu' nu etkin bir şekilde kullanır. | | | | | | | | | | | | | X | O | O | O | O |
| Araç Çubuğu' nun nerede yer aldığını bilir ve Araç Çubuğu' nu etkin bir şekilde kullanır. | | | | | | | | | | | | | X | O | O | O | O |
| Giriş Çubuğu' nun nerede yer aldığını bilir ve Giriş Çubuğu' nu etkin bir şekilde kullanır. | | | | | | | | | | | | | X | O | O | O | O |
| **10. İnşa adımları Dolaşma Çubuğu' nun nerede yer aldığını bilir ve İnşa adımları Dolaşma Çubuğu' nu etkin bir şekilde kullanır.** | | | | | | | | | | | | | | | | | |
| Menü Çubuğu' nda baştan 3. sırada bulunan Görünüm'e tıklar. Açılır menüde bulunan İnşa Protokolü'nü seçer. | | | | | | | | | | X | O | O | O | O | O | O | O |
| Menü Çubuğu' baştan 4. sırada bulunan Seçenekler' e tıklar. Açılır menüde bulunan Gelişmiş ikonunu seçer. Tercihler başlığı altında bir pencerenin açılacaktır. Açılan pencerede yatay menüde baştan ikinci sırada bulunan Grafik ikonuna tıklar. Açılan pencerede yatay menüde ilk sırada bulunan Temel'e tıklar. İnşa Adımları Dolaşma Çubuğu adıyla ayrılan bölümü bulur. | | | | | | | | | | X | O | O | O | O | O | O | O |
| **11. Grafik Penceresi' nin görünen Alanını değiştirir ve görünen Alanı ile ilgili ayarlamaları yapar.** | | | | | | | | | | | | | | | | | |
| Grafik Penceresi'ni Taşı ikonunu kullanarak değiştirir. | | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Grafik Penceresi' nin görünen Alanını yakınlaştırmak için Araç Çubuğu-Yakınlaştır adımlarını sırasıyla takip eder. | | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Grafik Penceresi' nin görünen Alanını yakınlaştırmak için fareyi kullanır. | | | | X | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Grafik Penceresi' nin görünen Alanını uzaklaştırmak için Araç Çubuğu-Uzaklaştır adımlarını sırasıyla takip eder. | | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Grafik Penceresi' nin görünen Alanını uzaklaştırmak için fareyi kullanır. | | | | X | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Grafik Penceresi' nin görünen Alanını değiştirmek için klavyedeki yön tuşlarını kullanır. | | | | | | | | | | | | | | | | X | O |
| **12. Eksenlerin ve ızgaraları etkin bir şekilde kullanır ve özelliklerini değiştirir.** | | | | | | | | | | | | | | | | | |
| Eksenleri gizlemek ve ya görünür yapmak için Grafik Penceresi üzerine sağ tıklar. Açılır menüde bulunan Grafik' i seçer. Eksenleri gizlemek için Eksenler Alanında bulunan Eksenleri Göster yazısının yanındaki kutudan tiki kaldırır; eksenler görünür yapmak için ise kutuya tik atar. | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O |

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| Eksenleri gizlemek ve ya görünür yapmak için Grafik Penceresi' nin sağ üst tarafında pencereye adını veren Grafik yazısını bulur. Bu yazının -Grafik- sol tarafında bulunan ok işaretine tıklar. Tıkladıktan sonra Grafik başlığının altında açılan bölümde bulunan Eksenleri Göster ve ya Sakla ikonuna tıklar. | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Eksenlerin kalınlığını ayarlamak için Grafik Penceresi üzerine sağ tıklar. Açılır menüde bulunan Grafik' i seçer. Tercihler başlıklı bir pencere açılacaktır. Eksenler kalın yapabilmek için Eksenler Alanında bulunan kutuya tik atar; eksenlerin kalınlığını azaltmak için is kutudan tiki kaldırır. | | | | | | X | O | O | O | O | O | O | O | O | O | O | O |
| Eksenlerin sitilini değiştirmek için Grafik Penceresi üzerine sağ tıklar. Açılır menüde bulunan Grafik' i seçer. Tercihler başlıklı bir pencere açılacaktır. Eksenler Alanında bulunan Doğru Sitili açılır menüsünü bulur ve istediği sitili seçer. | | | | | | X | O | O | O | O | O | O | O | O | O | O | O |
| Eksenlerin birimini ve aralığını değiştirmek için Grafik Penceresi üzerine sağ tıklar. Açılır menüde bulunan Grafik' i seçer. Yatay menüde 2. sırada bulunan xEkseni' ne tıklar. X ekseni ile ilgili ayarlamaları yapar. | | | | | | | | | | | | X | O | O | O | O | O |
| Eksenlerin rengini değiştirmek için Grafik Penceresi üzerine sağ tıklar. Açılır menüde bulunan Grafik' i seçer. Burada Eksenler Alanında bulunan Renk butonunu kullanarak eksenlerin rengini değiştirir. | | | | | | X | O | O | O | O | O | O | O | O | O | O | O |
| Izgaraları gizlemek ve ya görünür yapmak için Grafik Penceresi üzerine sağ tıklar. Açılır menüde bulunan Grafik' i seçer. Burada yatay menüde 4. sırada bulunan Grid' e tıklar. Izgaraları gizlemek için Izgarayı Göster yazısının yanındaki kutudan tiki kaldırır; görünür yapmak için ise kutuya tik atar. | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Izgaraları gizlemek ve ya görünür yapmak için Grafik Penceresi' nin sağ üst tarafında pencereye adını veren Grafik yazısını bulur. Bu yazının -Grafik- sol tarafında bulunan ok işaretine tıklar. Tıkladıktan sonra Grafik başlığının altında açılan bölümde bulunan Izgaraları Göster ve ya Sakla ikonuna tıklar. | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Izgaraların rengini değiştirmek için Grafik Penceresi üzerinde sağ tıklar. Açılır menüde bulunan Grafik' i seçer. Burada yatay menüde 4. sırada bulunan Grid' e tıklar. Bu kısımda bulunan Renk butonunu kullanarak ızgaraların rengini değiştirir. | | | | | | | | | | | | | | | | | X |
| **13. Matematiksel ve ya Geometrik hesaplamalar yapmak için Araç Çubuğu' nu etkin bir biçimde kullanır.** | | | | | | | | | | | | | | | | | |
| Açı ikonunu etkin bir şekilde kullanır. | | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Açıortay ikonunu etkin bir şekilde kullanır. | | | | | | | X | O | O | O | O | O | O | O | O | O | O |
| Alan ikonunu etkin bir şekilde kullanır. | | | | | | | | | | | | | | | | | X |
| Çevre İkonunu etkin bir şekilde kullanır. | | | | | | | | | | | | | | | | | X |
| Çokgen ikonunu etkin bir şekilde kullanır. | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Dik Doğru ikonunu etkin bir şekilde kullanır. | | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Doğru ikonunu etkin bir şekilde kullanır. | | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Doğruda Yansıt ikonunu etkin bir şekilde kullanır. | | | | | | | | | X | O | O | O | O | O | O | O | O |

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| Doğru Parçası ikonunu etkin bir şekilde kullanır. | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Düzgün çokgen ikonunu etkin bir şekilde kullanır. | | | | | | | | X | O | O | O | O | O | O | O | O | O |
| Elips ikonunu etkin bir şekilde kullanır. | | | | | | | | | | | | | X | O | O | O | O |
| Fonksiyon İnceleyici ikonunu etkin bir biçimde kullanır. | | | | | | | | | | | | | | | | X | O |
| Hiperbol ikonnunu etkin bir şekilde kullanır. | | | | | | | | | | | | | | X | O | O | O |
| Işın ikonunu etkin bir şekilde kullanır. | | | | | | X | O | O | O | O | O | O | O | O | O | O | O |
| İki Nesne Arasındaki İlişki ikonunu etkin bir şekilde kullanır. | | | | | X | O | O | O | O | O | O | O | O | O | O | O | O |
| İki Nesnenin Kesişimi ikonunu etkin bir şekilde kullanır. | | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| İki Nokta arasında Vektör İkonunu etkin bir şekilde kullanır. | | | | | | | | | | X | O | O | O | O | O | O | O |
| İki Noktadan Geçen Yarım Çember ikonunu etkin bir biçimde kullanır. | | | | | | | | | | | | | | | X | O | O |
| Merkez ve Bir Noktadan Geçen Çember İkonunu etkin bir şekilde kullanır. | | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Merkez ve İki Noktadan Geçen Çembersel Yay ikonunu etkin bir şekilde kullanır. | | | | | | | | | | | | | | | X | O | O |
| Çevre İkonunu etkin bir şekilde kullanır. | | | | | | | | | | | | | | | | | X |
| Çokgen ikonunu etkin bir şekilde kullanır. | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Dik Doğru ikonunu etkin bir şekilde kullanır. | | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Doğru ikonunu etkin bir şekilde kullanır. | | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Doğruda Yansıt ikonunu etkin bir şekilde kullanır. | | | | | | | | | X | O | O | O | O | O | O | O | O |
| Merkez ve Yarıçapla Çember ikonunu etkin bir şekilde kullanır. | | | | | | | | | | | | X | O | O | O | O | O |
| Nesne Üzerinde Nokta ikonunu etkin bir şekilde kullanır. | | | | | | | | | | | | | | | | X | O |
| Nesneyi Nokta Etrafında Dönder ikonunu etkin bir şekilde kullanır. | | | | | | | | | X | O | O | O | O | O | O | O | O |
| Nesneyi Noktada Yansıt ikonunu etkin bir şekilde kullanır. | | | | | | | | | X | O | O | O | O | O | O | O | O |
| Nesneyi Vektörle Ötele ikonunu etkin bir şekilde kullanır. | | | | | | | | | | X | O | O | O | O | O | O | O |
| Nokta ikonunu etkin bir şekilde kullanır. | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Noktadan Genişlet ikonunu etkin bir şekilde kullanır. | | | | | | | | X | O | O | O | O | O | O | O | O | O |
| Noktayı Bağla veya Ayır ikonunu etkin bir şekilde kullanır. | | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Orta nokta ve ya Merkez İkonunu etkin bir şekilde kullanır. | | | | | | | | X | O | O | O | O | O | O | O | O | O |
| Parabol ikonunu etkin bir şekilde kullanır. | | | | | | | | | | | | | | X | O | O | O |
| Paralel Doğru ikonunu etkin bir şekilde kullanır. | | | | | | | | | | | X | O | O | O | O | O | O |
| Pergel ikonunu etkin bir şekilde kullanır. | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Sabit Uzunluklu Kesim İkonunu etkin bir şekilde kullanır. | | | | | | | | | | | X | O | O | O | O | O | O |
| Teğet ikonunu etkin bir şekilde kullanır. | | | | | X | O | O | O | O | O | O | O | O | O | O | O | O |
| Uzaklık ve ya Uzunluk İkonunu etkin bir şekilde kullanır. | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Üç Noktadan Geçen Çember ikonunu etkin bir şekilde kullanır. | | | | | X | O | O | O | O | O | O | O | O | O | O | O | O |
| Verilen Ölçüde Açı ikonunu etkin bir şekilde kullanır. | | | | | | | | | | | | X | O | O | O | O | O |
| Yer Tanım İkonunu etkin bir şekilde kullanır. | | | | | | | | | | | | | | X | O | O | O |
| **14. Matematiksel ve geometrik hesaplamalar yapmak için Giriş Alanı' nı etkin bir şekilde kullanır.** | | | | | | | | | | | | | | | | | |

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| Abs(x) macro fonksiyonunu oluşturur ve etkin bir şekilde kullanır. | | | | | | | X | O | O | O | O | O | O | O | O | O | O |
| Açı[[<Nokta>, <Nokta>, <Nokta> ] macro fonksiyonunu oluşturur ve etkin bir biçimde kullanır. | | | | | | X | O | O | O | O | O | O | O | O | O | O | O |
| Açıortay[ <Nokta>, <Nokta>, <Nokta>] macro fonksiyonunu oluşturur ve etkin bir şekilde kullanır. | | | | | | | X | O | O | O | O | O | O | O | O | O | O |
| AğırlıkMerkezi[ <Çokgen> ] macro fonksiyonunu oluşturur ve etkin bir şekilde kullanır. | | | | | | | | X | O | O | O | O | O | O | O | O | O |
| Böl[ <Sayı>, <Sayı> ] macro fonksiyonunu oluşturur ve etkin bir şekilde kullanır. | | | | | | | | | | | X | O | O | O | O | O | O |
| Bölme yapmak için önceden hesapladığı uzaklıkları kullanır. | | | | | | | | | | | X | O | O | O | O | O | O |
| Çember[ <Nokta>, <Sayı> ] macro fonksiyonunu oluşturur ve etkin bir şekilde kullanır. | | | | | | | | | | | | | | | | | X |
| Çember[ <Nokta>, <Nokta>, <Nokta>] macro fonksiyonunu oluşturur ve etkin bir şekilde kullanır. | | | | | | | | | | | | | | | | | X |
| Çember[ <Nokta>, <Doğru parçası> ] macro fonksiyonunu oluşturur ve etkin bir şekilde kullanır. | | | | | | | | | | | | | | | | | X |
| Çokgen[ <Nokta>, <Nokta>, … <Nokta>] macro fonksiyonunu oluşturur ve etkin bir şekilde kullanır. | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Dikdoğru[ <Nokta>, <Doğru] macro fonksiyonunu oluşturur ve etkin bir şekilde kullanır. | | | | | | X | O | O | O | O | O | O | O | O | O | O | O |
| DeğeriVer[ <Nesne>, <Nesne> ] macro fonksiyonunu oluşturur ve etkin bir şekilde kullanır. | | | | | | | | | | | | | | X | O | O | O |
| Doğru[<Nokta>, <Nokta> ] macro fonksiyonunu oluşturur ve etkin bir şekilde kullanır. | | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Doğrultman[ <Konik> ] macro fonksiyonunu oluşturur ve etkin bir şekilde kullanır. | | | | | | | | | | | | | | X | O | O | O |
| DoğruParçası[<Nokta>, <Nokta> ] macro fonksiyonunu oluşturur ve etkin bir şekilde kullanır. | | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Döndür[ <Doğru>, <Açı>, <Nokta> ] macro fonksiyonunu oluşturur ve etkin bir şekilde kullanır. | | | | | | | | | | | | | | | X | O | O |
| Eğim [ <Doğru>] macro fonksiyonunu oluşturur ve etkin bir şekilde kullanır. | | | | | | | | | | | | | | | X | O | O |
| Işın[ <Başlangıç Noktası>, <Nokta> ] macro fonksiyonunu oluşturur ve etkin bir şekilde kullanır. | | | | | | | | | | | | | | | | X | O |
| Kesiştir[<Nesne>, <Nesne> ] macro fonksiyonunu oluşturur ve etkin bir şekilde kullanır. | | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| KoordinatAyarla[<Nokta>, <x>,< y> ] macro fonksiyonunu oluşturur ve etkin bir şekilde kullanır. | | | | | | | | | | X | O | O | O | O | O | O | O |
| Merkez[Konik] macro fonksiyonunu oluşturur ve etkin bir şekilde kullanır. | | | | | X | O | O | O | O | O | O | O | O | O | O | O | O |
| Noktanın adı ile koordinatlarını Giriş Alanı' na yazarak noktayı oluşturur. | | | | | | X | O | O | O | O | O | O | O | O | O | O | O |
| Odak[ <Konik> ] macro fonksiyonunu oluşturur ve etkin bir şekilde kullanır. | | | | | | | | | | | | | | X | O | O | O |

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| OrtaNokta[<Nokta>, <Nokta> ] macro fonksiyonunu oluştur ve etkin bir şekilde kullanır. | | | | | | | | | | X | O | O | O | O | O | O | O |
| Ötele[ <Resim>, <Vektör> ] macro fonksiyonunu oluşturur ve etkin bir şekilde kullanır. | | | | | | | | | | | | | X | O | O | O | O |
| Teğet[ <Nokta>, <Konik> ] macro fonksiyonunu oluşturur ve etkin bir şekilde kullanır. | | | | | | | | | | | | | | | X | O | O |
| Temel matematiksel işlemler yapmak için önceden soncunu bulduğu işlemleri kullanır. | | | | | | | | | | | | | | | X | O | O |
| Toplama yapmak için önceden hesapladığı uzaklıkları kullanır. | | | | | | | | | | | | | | X | O | O | O |
| Uzaklık[<Nokta>, <Nokta>] macro fonksiyonunu oluştur ve ikonunu etkin bir şekilde kullanır. | | | | | | | | X | O | O | O | O | O | O | O | O | O |
| Vektör[ <Nokta>, <Nokta> ] macro fonksiyonunu oluşturur ve etkin bir şekilde kullanır. | | | | | | | | | | X | O | O | O | O | O | O | O |
| YarımÇember[ <Nokta>, <Nokta> ] macro fonksiyonunu oluşturur ve etkin bir şekilde kullanır. | | | | | | | | | | | | | | | X | O | O |
| YerTanım[ <Yer tanım doğrusunu oluşturan nokta>, <Nokta> ] macro fonksiyonunu oluşturur ve etkin bir şekilde kullanır. | | | | | | | | | | | | | | X | O | O | O |
| **15. Matematiksel ve ya geometrik hesaplamalar yapmak için Araç Çubuğu' ndaki ikonlar ve Giriş Alanı' ndaki komutlar dışında kalan özelliklerden yararlanır.** | | | | | | | | | | | | | | | | | |
| Çokgenlerin iç bölgesine tıklayarak çokgenlerin iç açılarını ve ya dış açılarını bulur. | | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Açının aralık değerini değiştirmek için açının üzerine sağ tıklar. Açılır menüde bulunan Özellikler' i seçer. Açılan pencerede yatay menüde baştan 1. sırada bulunan Tercihler ikonuna tıklar. Açılan pencerede yatay menüde 1. sırada bulunan Temel'e tıklar. Bu pencere de Arasındaki Açı diye adlandırılan bir açılır menüyü bulur. İstediği aralığı seçer. | | | | | | | | | | | | | | | | X | O |
| Açının birimini değerini değiştirmek için açının üzerine sağ tıklar. Açılır menüde bulunan Özellikler' i seçer. Açılan pencerede yatay menüde baştan 5. sırada bulunan Gelişmiş ikonuna tıklar. İlk sırada bulunan Açı Birimi Alanında Radyan' ı ve ya Derece' yi işaretler. | | | | | | | | | | | | | | | | X | O |
| Kutupsal koordinatları ayarlamak için Menü Çubuğu' baştan 4. sırada bulunan Seçenekler' e tıklar. Açılır menüde bulunan Gelişmiş ikonunu seçer. Tercihler başlığı altında bir pencerenin açılır. Açılan pencerede yatay menüde ilk sırada bulunan Özellikler ikonuna tıklar Açılan pencerede yatay menüde 4. Sırada bulunan Cebir' e tıklar. Koordinatlar açılır menüsüne tıklar. Kutupsal koordinatları seçer. | | | | | | | | | X | O | O | O | O | O | O | O | O |
| Doğru grafiklerini oluşturmak için Giriş Alanı' na doğru denklemlerini yazar ve doğru grafiklerini oluşturur. | | | | | | | | | X | O | O | O | O | O | O | O | O |
| **16. Nesnelerin biçimlerini değiştirir.** | | | | | | | | | | | | | | | | | |

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| Noktanın sitilini değiştirmek için noktanın üzerine sağ tıklar ve açılır menüde bulunan Özelikler' i seçer. Tercihler başlığı altında açılan penceredeki Özellikler ikonuna tıklar ve yatay menüde 3. sırada bulunan Sitil'i seçer. Sitil Alanında bulunan Nokta Sitili adlı açılır menüdeki nokta sitili seçeneklerinden birini seçer. | | | | | X | O | O | O | O | O | O | O | O | O | O | O | O |
| Noktanın stilini değiştirmek için NoktaStiliAyarla[<Nokta>, <Sayı> ] macro fonksiyonunu oluşturur ve etkin bir biçimde kullanır. | | | | | X | O | O | O | O | O | O | O | O | O | O | O | O |
| Noktanın sitilini değiştirmek için Nokta Sitilini Ayarla ikonunu etkin bir şekilde kullanır. | | | | | X | O | O | O | O | O | O | O | O | O | O | O | O |
| Noktanın büyüklüğünü değiştirmek için noktanın üzerine sağ tıklar ve açılır menüde bulunan Özelikler' i seçer. Tercihler başlığı altında açılan penceredeki Özellikler ikonuna tıklar ve yatay menüde 3. sırada bulunan Sitil'i seçer Sitil Alanında bulunan Nokta Büyüklüğü sürgüsünü kullanarak noktanın kalınlığını değiştirir. | | | | | X | O | O | O | O | O | O | O | O | O | O | O | O |
| Noktanın büyüklüğünü değiştirmek için NoktaBüyüklük Ayarla[ <Nokta>, <Sayı>] macro fonksiyonunu oluşturur ve etkin bir biçimde kullanır. | | | | | X | O | O | O | O | O | O | O | O | O | O | O | O |
| Noktanın büyüklüğünü değiştirmek için Nokta Sitilini Ayarla ikonunu etkin bir şekilde kullanır. | | | | | X | O | O | O | O | O | O | O | O | O | O | O | O |
| Doğrunun, doğru parçasının ve ya ışının sitilini değiştirmek için doğrunun, doğru parçasını ve ya ışının üzerine sağ tıklar ve açılır menüde bulunan Özellikler' i seçer. Tercihler başlığı altında açılan penceredeki Özellikler ikonuna tıklar ve yatay menüde 3. sırada bulunan Sitil'i seçer Sitil Alanında bulunan Doğru Sitili adlı açılır menüdeki doğru sitili seçeneklerinden birini seçer. | | | | | X | O | O | O | O | O | O | O | O | O | O | O | O |
| Doğrunun, doğru parçasının ve ya ışının sitilini değiştirmek için DoğruStiliAyarla[<Doğru>, <Sayı> ] macro fonksiyonunu oluşturur ve etkin bir biçimde kullanır. | | | | | X | O | O | O | O | O | O | O | O | O | O | O | O |
| Doğrunun, doğru parçasının ve ya ışının sitilini değiştirmek için Doğru Sitilini Ayarla ikonunu etkin bir şekilde kullanır. | | | | | X | O | O | O | O | O | O | O | O | O | O | O | O |
| Doğrunun , doğru parçasının ve ya ışının kalınlığını değiştirmek için doğrunun, doğru parçasının ve ya ışının üzerine sağ tıklar ve açılır menüde bulunan Özelikler' i seçer. Tercihler başlığı altında açılan penceredeki Özellikler ikonuna tıklar ve yatay menüde 3. sırada bulunan Sitil'i seçer Sitil Alanında bulunan Doğru Kalınlığı sürgüsünü kullanarak doğrunun kalınlığını değiştirir. | | | | | X | O | O | O | O | O | O | O | O | O | O | O | O |
| Doğrunun , doğru parçasının ve ya ışının kalınlığını değiştirmek için DoğruKalınlıkAyarla[ <Doğru>, <Sayı>] macro fonksiyonunu oluşturur ve etkin bir biçimde kullanır. | | | | | X | O | O | O | O | O | O | O | O | O | O | O | O |
| Doğrunun, doğru parçasının ve ya ışının kalınlığını değiştirmek için Doğru Sitilini Ayarla ikonunu etkin bir biçimde kullanır. | | | | | X | O | O | O | O | O | O | O | O | O | O | O | O |

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| Açıya süsleme yapmak için süsleme yapmak istediği açıyı seçer. Bu açının üzerine sağ tıklar ve açılan menüde bulunan Grafik' i seçer. Tercihler başlığı altında açılan penceredeki Özellikler ikonuna tıklar ve yatay menüde 4. sırada bulunan Süsleme' yi seçer. Süsleme adlı açılır menüde bulunan seçeneklerden birini seçer. | | | | | | X | O | O | O | O | O | O | O | O | O | O | O |
| Dik açının sitilini değiştirmek için Menü Çubuğu' nda baştan 4. sırada bulunan Seçenekler'e tıklayın. Açılır menüden son sırada bulunan ikona tıklayarak Gelişmiş'i seçer. Tercihler başlığı altında açılan pencerede yatay menüde beşinci sırada bulunan Gelişmiş ikonuna tıklar. 2. sırada Dik Açı Sitili diye bir bölüm bulunmaktadır Bu bölümdeki dik açı sitillerinden birini seçer. | | | | | | | | X | O | O | O | O | O | O | O | O | O |
| **17. Grafik Penceresi' nin ve Grafik Penceresi üzerinde oluşturulan nesnelerin renklerini farklı değiştirir.** | | | | | | | | | | | | | | | | | |
| Grafik Penceresi' nin arka planını değiştirmek için Grafik Penceresi' nin üzerinde sağ tıklar ve açılır menüde bulunan Grafik' i seçer. Tercihler başlıklı pencere açılacaktır. Bu pencerenin içinde açılan Grafik bölümünde bulunan muhtelif Alanındaki Arka plan rengi butonunu kullanarak Grafik Penceresi' nin arka plan rengini değiştirir. | | | | | | X | O | O | O | O | O | O | O | O | O | O | O |
| Nesnenin rengini değiştirmek için nesnenin üzerine sağ tıklar ve açılır menüde bulunan Özellikler' i seçer. Tercihler başlığı altında açılan penceredeki Özellikler ikonuna tıklar ve yatay menüde 2. sırada bulunan Renk' i kullanır. Bu kısımda mevcut olan renkleri kullanarak nesnenin rengini değiştirir. | | | | X | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Nesnenin rengini değiştirmek için RenkAyarla[ <Nesne>, "<Renk>" ] macro fonksiyonunu oluşturur ve etkin bir biçimde kullanır. | | | | X | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Nesnenin rengini değiştirmek için Renk Ayarla ikonunu etkin bir şekilde kullanır. | | | | X | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Nesnenin rengini ve şeffaflığını değiştirmek için Renk ve Şeffaflık Ayarla ikonu etkin bir şekilde kullanır. | | | | | | | | | X | O | O | O | O | O | O | O | O |
| Nesnenin rengini değiştirmek için rengini değiştirmek istediği nesnenin üzerinde sağ tıklar. Açılır menüde bulunan Özellikler' i seçer. Tercihler başlığı altında bir pencere açılacaktır. Açılan pencerede yatay menüde baştan 1. sırada bulunan Tercihler ikonuna tıklar. Açılan pencerede yatay menüde 4. sırada bulunan Gelişmiş'e tıklar. Gelişmiş başlığı altında açılan bölümdeki renkleri kullanarak Değişken Renkler oluşturur. | | | | | | | | | | | | | | | | X | O |
| **18. Grafik Penceresi üzerine metin ekler, eklediği metinlerin biçimini değiştirir ve Metin Penceresi' ni etkin bir biçimde kullanır.** | | | | | | | | | | | | | | | | | |
| Metin eklemek için Araç Çubuğu' nda bulunan Metin ikonunu seçer ve etkin bir biçimde kullanır. | | | | | | X | O | O | O | O | O | O | O | O | O | O | O |
| Metin Eklemek için Metin Penceresi' nde bulunan Nesneler açılır menüsünü etkin bir şekilde kullanır. | | | | | | X | O | O | O | O | O | O | O | O | O | O | O |
| Metin eklemek için Metin[ <Nesne> ] macro fonksiyonunu oluşturur ve etkin bir biçimde kullanır. | | | | | | | | | | | | | | | X | O | O |

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| Simge eklemek için Metin Penceresi' nde bulunan Simgeler açılır menüsünü etkin bir şekilde kullanır. | | | | | | X | O | O | O | O | O | O | O | O | O | O | O |
| Metin alanı eklemek için Araç Çubuğu' nda bulunan Metin Alanı Ekle ikonunu etkin bir biçimde kullanır. | | | | | | | | | X | O | O | O | O | O | O | O | O |
| Metin yazısının yazı biçimini değiştirmek için metinin üzerine sağ tıklar ve açılır menüde bulunan Özellikler' i seçer. Tercihler başlığı altında açılan penceredeki Özellikler ikonuna tıklar ve yatay menüde 2. sırada bulunan Metin'i seçer. Yazı biçimini değiştirmek için oluşturulan açılır menüyü kullanarak yazı biçimini değiştirir. | | | | | | | | | | | | | | | | X | O |
| Metinin büyüklüğünü değiştirmek için metinin üzerine sağ tıklar ve açılır menüde bulunan Özellikler' i seçer. Tercihler başlığı altında açılan penceredeki Özellikler ikonuna tıklar ve yatay menüde 2. sırada bulunan Metin'i seçer. Metin Büyüklüğünü Ayarlamak için oluşturulan açılır menüyü kullanarak metinin büyüklüğünü değiştirir. | | | | | | X | O | O | O | O | O | O | O | O | O | O | O |
| Metin büyüklüğünü değiştirmek için Metin Büyüklüğünü Ayarla ikonunu etkin bir şekilde kullanır. | | | | | | X | O | O | O | O | O | O | O | O | O | O | O |
| Metinin kalınlığını değiştirmek için metinin üzerine sağ tıklar ve açılır menüde bulunan Özellikler' i seçer. Tercihler başlığı altında açılan penceredeki Özellikler ikonuna tıklar ve yatay menüde 2. sırada bulunan Metin'i seçer. Bu kısımda yazı tipinin kalınlığını ayarlamak için bulunan butonu seçili hale getirerek yazı tipinin kalınlığını arttırır; seçili durumdan çıkararak ise yazı tipinin kalınlığını azaltır. | | | | | | X | O | O | O | O | O | O | O | O | O | O | O |
| Metin kalınlığını ayarlamak için Yazı Sitilini Kalın Ayarla ikonunu etkin bir biçimde kullanır. | | | | | | X | O | O | O | O | O | O | O | O | O | O | O |
| Metin yazısını yatık ve ya düz yapmak için metinin üzerine sağ tıklar ve açılır menüde bulunan Özellikler' i seçer. Tercihler başlığı altında açılan penceredeki Özellikler ikonuna tıklar ve yatay menüde 2. sırada bulunan Metin'i seçer. Bu kısımda yazı tipinin yatık ya da düz oluşunu ayarlamak için bulunan butonu seçili duruma getirerek yazı tipini yatık ayarlar; seçili durumdan çıkararak ise yazı tipini düz yapar. | | | | | | | | X | O | O | O | O | O | O | O | O | O |
| Metin yazısını yatık ya da düz yapmak için Yazı Tipini Yatık Ayarla ikonunu etkin bir şekilde kullanır. | | | | | | | | | | | | | | | | X | O |
| Metinin rengini değiştirmek için metinin üzerine sağ tıklar ve açılır menüde bulunan Özellikler' i seçer. Tercihler başlığı altında açılan penceredeki Özellikler ikonuna tıklar ve yatay menüde 3. sırada bulunan Renk' i seçer. Bu kısımda bulunan Kalem rengini seçtikten sonra metinin rengi için istediği bir rengi belirler. | | | | | | X | O | O | O | O | O | O | O | O | O | O | O |
| Metin rengini değiştirmek için Metin Rengini Ayarla ikonunu etkin bir şekilde kullanır. | | | | | | X | O | O | O | O | O | O | O | O | O | O | O |
| Metinin arka plan rengini değiştirmek için metinin üzerine sağ tıklar ve açılır menüde bulunan Özellikler' i seçer. Tercihler başlığı altında açılan penceredeki Özellikler ikonuna tıklar ve yatay menüde 3. sırada bulunan Renk' i seçer. Bu kısımda bulunan Arka plan Rengini seçtikten sonra metinin arka plan rengi için istediği bir rengi belirler. | | | | X | O | O | O | O | O | O | O | O | O | O | O | O | O |

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| Metinin arka plan rengini değiştirmek için ArkaplanRenginiAyarla[ <Nesne>, "<Renk>" ] komutunu kullanır. | | | | X | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Metinin arka plan rengini değiştirmek için Arka plan Rengini Ayarla ikonunu etkin bir şekilde kullanır. | | | | X | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Metin Penceresi' nde yer alan Latex formülünü etkin bir biçimde kullanır. | | | | | | | X | O | O | O | O | O | O | O | O | O | O |
| **19. Resim eklemek için Araç Çubuğu-Resim Ekle adımlarını sırasıyla takip eder.** | | | | | | | | X | O | O | O | O | O | O | O | O | O |
| **20. Düğme eklemek için Araç Çubuğu-Düğme Ekle adımlarını sırasıyla takip eder.** | | | | | | | | | | | | | | X | O | O | O |
| **21. GeoGebra' nın dinamik yazılım olma özelliğini keşfeder ve bu amaca yönelik aktiviteler oluşturur.** | | | | | | | | | | | | X | O | O | O | O | O |
| **22. Sürgü oluşturur ve oluşturduğu sürgünün özelliklerini değiştirir.** | | | | | | | | | | | | | | | | | |
| Araç Çubuğu-Sürgü adımlarını sırasıyla takip eder ve ve Sayısal sürgüsü oluşturur. | | | | | | | | | | | | | | | X | O | O |
| Sürgünün özelliklerini değiştirmek için sürgünün üzerine sağ tıklar ve açılır menüde bulunan Özellikler' i seçer. Tercihler başlığı altında açılan penceredeki Özellikler ikonuna tıklar ve yatay menüde 2. sırada bulunan Sürgü' yü seçer. Bu kısımda bulunan sürgü ile ilgili tüm özellikleri değiştirir. | | | | | | | | | | | X | O | O | O | O | O | O |
| GeoGebra tarafından Sürgülere nasıl ad verildiğini anlar. | | | | | | | | | | | | | | | | X | O |
| **23. Noktaların sadece noktalara özgü olan özelliklerini etkin bir şekilde kullanır.** | | | | | | | | | | | | | | | | | |
| Metinin arka plan rengini değiştirmek için metinin üzerine sağ tıklar ve açılır menüde bulunan Özellikler' i seçer. Tercihler başlığı altında açılan penceredeki Özellikler ikonuna tıklar ve yatay menüde 3. sırada bulunan Renk' i seçer. Bu kısımda bulunan Arka plan Rengini seçtikten sonra metinin arka plan rengi için istediği bir rengi belirler. | | | | X | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Noktayı canlandırmak için noktayı seçer ve üzerine sağ tıklar. Açılır menüde bulunan Özellikler' i seçer. Tercihler başlığı altında bir pencere açılacaktır. Tercihler başlığı altında açılan pencere de yatay menüde 1. sırada bulunan Temel'e tıklar. Temel başlığı altında bulunan Canlandırılıyor yazısının yanındaki kutuya tik atar. | | | | | | | | | | | | | | X | O | O | O |
| Noktayı canlandırmak için noktayı seçer, üzerine sağ tıklar ve açılır menüde bulunan Canlandırılıyor' u seçer. | | | | | | | | | | | | | | | X | O | O |
| Noktanın izini açmak için noktayı seçer ve üzerine sağ tıklar ve açılır menüde bulunan İzi Aç' ı seçer. | | | | | | | | | | | | | | X | O | O | O |
| Noktayı hareket ettirmek için klavyede bulunan + ve – tuşlarını etkin bir biçimde kullanır. | | | | | | | | | | | | | | | | X | O |
| Noktayı hareket ettirmek için klavye de bulunan yön tuşlarını etkin bir biçimde kullanır. | | | | | | | | | | | | | | | | X | O |
| Noktaların renkleri ile bu renklere bağlı olarak değişen dinamik nokta olabilme derecesi arasındaki ilişkiyi kavrar. | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| **24. Boolean değerinin tanımını yapar ve örneklerle açıklar.** | | | | | | | | | | | X | O | O | O | O | O | O |

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| **25. Betikleme özelliğini etkin bir biçimde kullanır.** | | | | | | | | | | | | | | | | | |
| Nesnenin üzerine sağ tıklar. Açılır menüde bulunan Özellikler' i seçer. *Tercihler* başlığı altında bir pencere açılır. Açılan pencerede Yatay Menü' de baştan 1. sırada bulunan Tercihler ikonuna tıklar. Açılan pencerede yatay menüde 5. sırada bulunan Betikleme' ye tıklar. Alt yatay menüde 1. sırada bulunan Güncellendiğinde' ye tıklar. | | | | | | | | | | | | | | X | O | O | O |
| Nesnenin üzerine sağ tıklar. Açılır menüde bulunan Özellikler' i seçer. *Tercihler* başlığı altında bir pencere açılır. Açılan pencerede Yatay Menü' de baştan 1. sırada bulunan Tercihler ikonuna tıklar. Açılan pencerede yatay menüde 5. sırada bulunan Betikleme' ye tıklar. Alt yatay menüde 1. sırada bulunan Tıklandığında' ya tıklar. | | | | | | | | | | | | | | | | X | O |
| **26. Nesneleri farklı biçimlerde seçer.** | | | | | | | | | | | | | | | | | |
| Nesne seçmek için nesnenin üzerine tıklar. | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Nesneyi seçmek için nesneyi Cebir Penceresi' nde bulur ve nesnenin üzerine tıklar. | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Nesneyi seçmek için nesnenin üzerine sağ tıklar açılır menüde bulunan Özellikler' i seçer. Tercihler başlığı altında açılan pencerenin sol Alanındaki beyaz bölmede seçmek istediği nesneyi bulur ve üzerine tıklar. | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Nesne seçmek için Nesneleri Taşı ikonunu etkin bir biçimde kullanır. | | | | | | | | X | O | O | O | O | O | O | O | O | O |
| Nesne seçmek için NesneleriSeç[ ] macro fonksiyonunu oluşturur ve etkin bir biçimde kullanır. | | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Birden fazla nesne seçebilmek için Ctrl tuşunu etkin bir biçimde kullanır. | | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Birden fazla nesne seçmek için Grafik Penceresi üzerinde dikdörtgen oluşturur. | | | | | | | | | X | O | O | O | O | O | O | O | O |
| **27. Nesneleri gizler ve ya nesnelerin gösterir.** | | | | | | | | | | | | | | | | | |
| Cebir Penceresi' ni gizlemek ve ya görünür yapabilmek için Görünüm-Cebir Penceresi adımlarını sırasıyla takip eder. | | | | | | | | | | | | | | | | | X |
| Hesap Çizelgesi' ni gizlemek ve ya görünür yapabilmek için Görünüm-Hesap Çizelgesi Görünüm adımlarını sırasıyla takip eder. | | | | | | | | | | | | X | O | O | O | O | O |
| Giriş Alanını gizlemek ve ya görünür yapabilmek için Görünüm-Giriş Alanı adımlarını sırasıyla takip eder. | | | | | | | | | | | | | | | | | X |
| Grafik Penceresi' ni gizlemek ve ya görünür yapabilmek için Grafik Penceresi adımlarını sırasıyla takip eder. | | | | | | | | | | | | | | | | | X |
| Nesneyi gizlemek için nesnenin üzerine sağ tıklar ve açılır menüde bulunan Özelikler' i seçer. Tercihler başlığı altında açılan pencerenin sol Alanındaki beyaz bölmede seçmek istediği nesneyi bulur ve nesnenin yanındaki daireye tıklar; göstermek için ise çembere tıklar. | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Düzenle-Nesneleri Göster/Sakla adımlarını sırasıyla takip eder. | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Araç Çubuğu-Nesneyi Göster/Gizle adımlarını sırasıyla takip eder. | | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| NesneyiGöstermeŞartıAyarla[ <Nesne>, <Şart> ] macro fonksiyonunu oluşturur ve etkin bir şekilde kullanır. | | | | | | | | | | | | | X | O | O | O | O |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nesneyi göstermek için nesnenin üzerine sağ tıklar ve açılır menüde bulunan Nesneyi Göster ikonunu seçili hale getirir; nesneyi gizlemek için ise Nesneyi Göster ikonunu seçili durumdan çıkarır. | | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Nesnenin adını Cebir Penceresi' nde bulur. Nesneyi göstermek için nesnenin isminin yanındaki çembere tıklar; gizlemek için ise nesnenin isminin yanındaki daireye tıklar. | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| İşaret Kutusu ikonunu etkin bir biçimde kullanır. | | | | | | | | | | | X | O | O | O | O | O | O |
| Nesnenin üzerine sağ tıklar ve açılır menüde bulunan Özelikler' i seçer. Tercihler başlığı altında açılan penceredeki Özellikler ikonuna tıklar ve yatay menüde 4. sırada bulunan Gelişmiş' i seçer. Bu kısımdaki Nesneyi Gösterme Şartı'nı kullanır. | | | | | | | | | | | X | O | O | O | O | O | O |
| **28. Nesnelerin konumlarını değiştirir, sabitler ve nesneleri hareket edebilme derecelerine göre gruplar.** | | | | | | | | | | | | | | | | | |
| Cebir Penceresi' ni konumunu aşağıda duracak şekilde ayarlamak için Cebir Penceresi' ni Cebir Penceresi adının yazılı olduğu Alanından tutar ve aşağıya doğru sürükler; sol tarafta duracak şekilde ayarlamak için Cebir Penceresi adının yazılı olduğu Alanından tutar ve sola doğru sürükler; sağ tarafta duracak şekilde ayarlamak için Cebir Penceresi adının yazılı olduğu Alanından tutar ve sağa doğru sürükler. | | | | | | | | | | | | | | | | | X |
| Nesnenin üzerine tıklar ve Grafik Penceresi üzerinde sürükler. | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Nesnenin konumunu değiştirmek için Taşı ikonunu etkin bir şekilde kullanır. | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Resmin köşe noktalarını kullanarak resmin konumunu ya da büyüklüğünü değiştirmek için resmin üzerine sağ tıklar ve açılır menüde bulunan Özellikler' i seçer. Tercihler başlığı altında açılan penceredeki Özellikler ikonuna tıklar ve yatay menüde 4. sırada bulunan Yer' i seçer. Köşe noktalarının konumunu Grafik Penceresi üzerinde oluşturduğu noktalar aracılığı ile değiştirir. | | | | | | | | | | | X | O | O | O | O | O | O |
| Köşe[ <Resim>, <Sayı> ] macro fonksiyonunu oluşturur ve etkin bir şekilde kullanır. | | | | | | | | | | | | | | | X | O | O |
| Nesneyi sabitlemek için nesnenin üzerine sağ tıklar açılır menüde bulunan Özellikler' i seçer. Tercihler başlığı altında açılan pencerede bulunan Özellikleri seçer. Özellikler Alanındaki yatay menüde ilk sırada bulunan Temel Alanına tıklar. Bu kısımda bulunan Nesneyi Sabitle isimli kutuya tik atar ve ya atılan tiki kaldırır. | | | | | | | | X | O | O | O | O | O | O | O | O | O |
| Bağımlı, yardımcı ve bağımsız nesnenin tanımını yapar ve örneklerle açıklar. | | | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| **29. Nesneleri siler.** | | | | | | | | | | | | | | | | | |
| Araç Çubuğu-Sil adımlarını sırasıyla takip eder. | | | | X | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Düzenle-Sil adımlarını sırasıyla takip eder. | | | | X | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Backspace tuşunu kullanır. | | | | X | O | O | O | O | O | O | O | O | O | O | O | O | O |
| **30. Grafik Penceresi üzerinde oluşturulan nesneleri farklı biçimlerde etkiler ve etiketlerin özelliklerini değiştirir.** | | | | | | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Etiketini göstermek ve ya gizlemek için nesnenin üzerine sağ tıklar ve açılır menüde bulunan Özellikler' i seçer. Tercihler başlığı altında açılan penceredeki Özellikler ikonuna tıklar ve yatay menüde 1. sırada bulunan Temel'i seçer. Nesnenin etiketimi gizlemek için Temel Alanında Etiketi Göster adlı kutudaki tiki kaldırır; göstermek için ise kutuya tik atar. | | | | | | | | | | | | | | | X | O | O |
| Etiketini göstermek ve ya gizlemek için Düzenle-Etiketleri Göster/Sakla adımlarını sırasıyla takip eder. | | | | | | | | | | | | | | | X | O | O |
| Etiketini göstermek ve ya gizlemek için nesnenin üzerine sağ tıklar ve açılır menüde bulunan Etiketi Göster ikonunu etkin bir şekilde kullanır. | | | | | | | | | | | | | | | X | O | O |
| Etiketini göstermek ve ya gizlemek için Araç Çubuğu-Etiketi Göster/Gizle adımlarını sırasıyla takip eder. | | | | | | | | | | | | | | | X | O | O |
| Etiketini değiştirmek için nesnenin üzerine sağ tıklar. Açılır menüde bulunan Özellikler' i seçer. Tercihler başlığı altında açılan penceredeki Özellikler ikonuna tıklar ve yatay menüde 1. sırada bulunan Temel'i seçer. Temel Alanındaki Ad bölümünde nesnelere vermek istediği adı yazar. | | | | | | | X | O | O | O | O | O | O | O | O | O | O |
| Etiketini değiştirmek için nesnenin üzerine sağ tıklar. Açılır menüde bulunan Ad Değiştir ikonunu etkin bir biçimde kullanır. | | | | | | | | X | O | O | O | O | O | O | O | O | O |
| Tanımını değiştirmek için nesnenin üzerine sağ tıklar. Açılır menüde bulunan Özellikler' i seçer. Tercihler başlığı altında bir pencere açılacaktır. Tercihler başlığı altında açılan pencere de yatay menüde 1. sırada bulunan Temel'e tıklar. Temel başlığı altında açılan bölümde Ad yazan bölümün altında Tanım diye bir bölümü bulur. Bu bölüm üzerinde gerekli düzenlemeleri yapar ve nesnenin tanımını değiştirir. | | | | | | | | | | | | | X | O | O | O | O |
| Etiketini değiştirmek için nesneyi seçer ve nesnenin üzerine sağ tıklar. Açılır menüde bulunan Özellikler' i seçer. Tercihler başlığı altında bir pencere açılacaktır. Tercihler başlığı altında açılan pencere de yatay menüde 1. sırada bulunan Temel'e tıklar. Temel başlığı altında açılan pencerede yer alan Etiketi Göster yazısını bulur. Etiketi Göster yazısının sağında bulunan açılır listeye tıklayın. Açılır listede bulunan Ad, Ad & Değer, Değer ve Başlık seçeneklerinden birini seçer. | | | | | | X | O | O | O | O | O | O | O | O | O | O | O |
| Etiket sitilini değiştirmek için Grafik başlıklı pencerenin Grafik yazısının hizasında bulunan Etiket Sitilini Değiştir ikonunu kullanarak değiştirir. | | | | | | | | | | | | | | | | | X |
| Etiketlendirme biçimini otomatik olarak ayarlamak için Menü Çubuğu' nda bulunan Seçenekler' e tıklar. Açılır menüde bulunan Etiketlendirme' yi seçer. Sunulan seçenekler arasından istediğini seçer. | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Nesneler ile nesnelere etiket olarak verilen harflerin büyüklükleri arasındaki ilişkiyi kavrar. | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| **31. GeoGebra' da kullanılan dili değiştirmek için Seçenekler-Dil adımlarını sırasıyla takip eder.** | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| **32. Nesneleri kopyalamak için Düzenle-Kopyala adımlarını sırasıyla takip eder.** | | | | | | | | X | O | O | O | O | O | O | O | O | O |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **33. Kopyalanan nesneleri yapıştırmak için Düzenle-Yapıştır adımlarını sırasıyla takip eder.** | | | | | | | | X | O | O | O | O | O | O | O | O | O |
| **34. Grafiklerin görmenin dışında işitme duyusuna da hitap edebilmesi amacıyla GeoGebra'nın ses çıkarma özeliğini oluşturduğu grafiklere uygular.** | | | | | | | | | | | | | | | | X | O |
| **35. Yapılan işlemleri geriye alabilir ve ya geriye alınan işlemleri yeniden yapabilir.** | | | | | | | | | | | | | | | | | |
| Yapılan işlemleri geri almak için Düzenle-Geri Al adımlarını sırasıyla takip eder. | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Yapılan işlemleri geri almak için Geri Al ikonunu kullanır. | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Yapılan işlemleri geri almak için ctrl+z tuş kombinasyonunu kullanır. | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Geriye alınan işlemleri yeniden yapmak için Düzenle-Yeniden Yap adımlarını sırasıyla takip eder. | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Geriye alınan işlemleri yeniden yapmak için Yeniden Yap ikonunu kullanır. | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Geriye alınan işlemleri yeniden yapmak için ctrl+y tuş kombinasyonunu kullanır. | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| **36. Dosyalarını farklı biçimlerde kaydederler.** | | | | | | | | | | | | | | | | | |
| Dosyalarını kaydetmek için Dosya-Kaydet adımlarını sırasıyla takip eder. | X | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| Dosyalarını kaydetmek için Dosya –Farklı Kaydet adımlarını sırasıyla takip eder | | | | | | | | | | | | | | | | | X |
| Dosyalarını Web sayfası olarak kaydetmek için Dosya-Çıkart- Websayfası Olarak Dinamik Çalışma Sayfası adımlarını sırasıyla takip eder. | | | | | | | | | | | | | | | | X | O |
| Dosyalarını Web sayfası olarak kaydetmek için İnşa Adımları Dolaşma Çubuğu-Websayfası olarak Aktar adımlarını sırasıyla takip eder | | | | | | | | | | X | O | O | O | O | O | O | O |
| Dosyalarını yazdırmak için İnşa Adımları Dolaşma Çubuğu-Yazdır adımlarını sırasıyla takip eder. | | | | | | | | | | X | O | O | O | O | O | O | O |
| Dosyalarını resim olarak çıkartmak ve başka bir dosyaya yapıştırabilmek için Dosya-Çıkart-Çizim Tahtası'ndan Panoya adımlarını sırasıyla takip eder. | | | | | | | | | | | | | | | | | X |
| Dosyalarını resim olarak çıkartmak ve başka bir dosyaya yapıştırmak için Düzenle-Grafik Penceresindan Panoya adımlarını sırasıyla takip eder | | | | | | | | | | | | | | | | | X |
| Dosyalarını resim olarak çıkartmak ve başka bir dosyaya yapıştırabilmek için Dosya-Çıkart-Resim Olarak Grafik Görünümü adımlarını sırasıyla takip eder. | | | | | | | | | | | | | | | | | X |
| Dosyalarını GeoGebra sitesine yüklemek için Dosya Dosya-Paylaş adımlarını sırasıyla takip eder. | | | | | | | | | | | | | | | | | X |

# APPENDIX C: Matching GeoGebra training objectives with MoNE high school mathematics curriculum objectives

| | 16-4 | 9-1 | 9-1 | 3-1 | 11-2 | 11-2 | 11-1 | 7-2 | 7-2 | 8-1 | 8-2 | 8-2 | 13-1 | 12-1 | 12-1 | 17-8 | 10-1 | 7-1 | 9-3 | 16-3 | 1-1, 2-1, 2-2, 3-2, 4-1 | 17-8 | 17-8 | 16-3 | 17-4, 17-5, 17-6, 17-7 | 17-1, 17-2, 17-3 | 17-8 | 6-2 | 15-1, 16-1, 16-2 | 9-2, 9-4, 11-3 | 10-2 | 17-8 | 6-1, 2-3 | 5-1 | 5-1 | 13-2, 14-1, 14-2, 14-3, 14-4 | 11-1 | 11-1 | 6-2 | 15-1, 16-1, 16-2 | 15-1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 9.4.1.1. | 9.4.1.2. | 9.4.1.3. | 9.4.1.4. | 9.4.2.1 | 9.4.2.2 | 9.4.2.3 | 9.4.3.1. | 9.4.3.2. | 9.4.3.3. | 9.4.3.4. | 9.4.3.5. | 9.4.4.1. | 9.4.4.2. | 9.4.4.3. | 9.4.5.1. | 9.5.1.1 | 10.4.1.1. | 10.4.1.3. | 10.5.1.1. | 10.5.2.1. | 10.5.2.2. | 10.5.2.3. | 10.5.3.1 | 10.8.1.2. | 10.8.3.1. | 10.8.4.1. | 11.4.1.1. | 11.4.2.1. | 11.7.1.1. | 11.7.2.1. | 11.4.1. | 12.3.1.1. | 12.3.1.2. | 12.3.1.3 | 12.3.2.1. | 12.3.1. | 12.3.2. | 12.4.1 | 12.4.2. | 12.4.3. |
| 1. | | | | | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2. | | | | | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3. | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4. | | | | | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5. | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6. | | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7. | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8.1 | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8.2. | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8.3. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | X | |
| 8.4. | | | | | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8.5. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | |
| 9.1. | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9.2. | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9.3. | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10.1. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | |
| 10.2. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | |
| 11.1. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 11.2. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 11.3. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 11.4. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 11.5. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 11.6. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | X | |
| 12.1. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 12.2. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 12.3. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | |
| 12.4. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | X | | | | | | | | | | | X | | |
| 12.5. | | | | | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12.6. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | |
| 12.7. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 12.8. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 12.9. | | | | | | | | | | | | | | | | X | | | | | | X | X | | | | X | | | | | X | | | | | | | | | |
| 13.1. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 13.2. | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13.3. | | | | | | | | | | | | | | | | X | | | | | | X | X | | | | X | | | | | X | | | | | | | | | |
| 13.4. | | | | | | | | | | | | | | | | X | | | | | | X | X | | | | X | | | | | X | | | | | | | | | |
| 13.5. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 13.6. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 13.7. | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13.8. | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

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| 13.9. | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 13.10. | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13.11. | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13.12. | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | X | |
| 13.13. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | |
| 13.14. | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | X | | |
| 13.15. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | |
| 13.16. | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13.17. | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | |
| 13.18. | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | X | X |
| 13.19. | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 13.20. | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | X | X |
| 13.21. | | | | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13.22. | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | |
| 13.23. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | |
| 13.24. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | |
| 13.25. | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | |
| 13.26. | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 13.27. | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13.28. | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13.29. | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13.30. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | |
| 13.31 | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13.32. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | |
| 13.33 | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | |
| 13.34 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | |
| 13.35 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | |

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| 13.36 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | | |
| 13.37 | | | | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13.38 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | |
| 14.1. | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | |
| 14.2. | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | X | | | |
| 14.3. | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 14.4. | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 14.5. | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | |
| 14.6. | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 14.7. | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | |
| 14.8. | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | |
| 14.9. | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | |
| 14.10. | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | |
| 14.11. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | |
| 14.12. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | |
| 14.13. | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 14.14. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | |
| 14.15. | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | |
| 14.16. | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | X | X |
| 14.17. | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | X | X |
| 14.18. | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 14.19. | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | |
| 14.20. | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | |
| 14.21. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | | |
| 14.22. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | |
| 14.23. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | |
| 14.24. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | |

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| 14.25. | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 14.26. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | X | X |
| 14.27. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | X | X |
| 14.28. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | |
| 14.29. | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 14.30. | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | |
| 14.31. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | X | X |
| 14.32. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | |
| 15.1. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 15.2. | | | | | | | | | | | | | | | | | | | | X | | | | X | | | | | | | | | | | | | | | | | |
| 15.3. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | X | |
| 15.4. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | |
| 15.5. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | |
| 16.1. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | |
| 16.2. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | |
| 16.3. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | |
| 16.4. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | |
| 16.5. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | |
| 16.6. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | |
| 16.7. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | |
| 16.8. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | |
| 16.9. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | |
| 16.10. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | |
| 16.11. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | |
| 16.12. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | |
| 16.13. | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | X | | |
| 16.14. | | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

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| 17.1. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | |
| 17.2. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 17.3. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 17.4. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 17.5. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | |
| 17.6. | | | | | | | | | | | | | | | | | | | | X | | | | X | | | | | | | | | | | | | | | | | |
| 18.1. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | |
| 18.2. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | |
| 18.3. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | X | X |
| 18.4. | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | X | | |
| 18.5. | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | |
| 18.6. | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 18.7. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | |
| 18.8. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | |
| 18.9. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | |
| 18.10. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | |
| 18.11. | | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 18.12. | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 18.13. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | |
| 18.14. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | |
| 18.15. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 18.16. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 18.17. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 18.18. | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | |
| 19. | | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 20. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | |
| 21. | | | | | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | |

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| 22.1. | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | X | |
| 22.2. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | |
| 22.3. | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 22.4. | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | X |
| 22.5. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | |
| 22.6. | | | | | | | | | | | | | | | | | | | X | | | | X | | | | | | | | | | | | | | | | | |
| 23.1. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | |
| 23.2. | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | X | X |
| 23.3. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | |
| 23.4. | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | X | |
| 23.5. | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | X | |
| 23.6. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | |
| 24. | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 25.1. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | |
| 25.2. | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | X | |
| 26.1. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | |
| 26.2. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | |
| 26.3. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | |
| 26.4. | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 26.5. | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 26.6. | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 26.7. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | |
| 27.1. | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | |
| 27.2. | | | | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 27.3. | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | |
| 27.4. | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | |
| 27.5. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | |

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| 27.6. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | |
| 27.7. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 27.8. | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 27.9. | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 27.10. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | |
| 27.11. | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 27.12. | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 28.1. | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | |
| 28.2. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 28.3. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 28.4. | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | |
| 28.5. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | X | X |
| 28.6. | | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 28.7. | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 29.1. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 29.2. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 29.3. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 30.1. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | X | X |
| 30.2. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | X | X |
| 30.3. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | X | X |
| 30.4. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | X | X |
| 30.5. | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 30.6. | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 30.7. | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 30.8. | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | X | | |
| 30.9. | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | |
| 30.10. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |

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| 30.11. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 31. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 32. | | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 33. | | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 34. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | X | |
| 35.1. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 35.2. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 35.3. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 35.4. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 35.5. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 35.6. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 36.1. | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| 36.2. | | | | | | | | | | | | | | | | X | | | | | | X | X | | | | X | | | | | X | | | | | | | | | |
| 36.3. | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 36.4. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | |
| 36.5. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | |
| 36.6. | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | |
| 36.7. | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | |
| 36.8. | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | |
| 36.9. | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | |