MODELING UNIVERSITY STUDENTS' DERIVATIVE CONCEPTIONS IN CALCULUS

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

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ABSTRACT

MODELING UNIVERSITY STUDENTS' DERIVATIVE CONCEPTIONS IN CALCULUS

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The aim of this study is to understand how prerequisite knowledge of derivative considered with the cognitive levels is related to the attainment of derivative concepts among the Turkish university students with the consideration of student related characteristics. The cognitive levels addressed in the study are retrieval, comprehension, analysis, and knowledge utilization cognitive processes. Moreover student related characteristics are socioeconomic status, mathematics motivation, mathematics anxiety, derivative self-efficacy, and the demographic profiles.

Structural equation modeling was used to test the hypothesized relationships of student related characteristics, the four cognitive levels in the prerequisite concepts of derivative, and in the concept of derivative. Exploratory and confirmatory factor analysis were carried out to determine the observed variables representing the latent variables.

According to the present study, for higher achivement in derivative, different groups of skills should be considered. Almost all of the cognitive levels are important to achieve learning in derivative, including the retrieval outcomes. All the groups have different relations with the achievement in derivative with different magnitudes. In terms of prerequisite skills, the most important variable is the knowledge utilization. In general, both analysis and knowledge utilization are the two domains which are definitely required for the learning achievement of derivative concepts. For a successful teaching of derivative, the prerequisite knowledge and skills, and four groups of cognitive tasks should be considered in the course plannings. Students' affective variables and their socio economic status did not give strong relations with the cognitive variables.

With the help of the findings, it can be concluded that different groups of cognitive skills should be considered in calculus teaching settings. Teachers should consider the cognitive skills of the students into account during their teaching. Teachers should be avare of the fact that students need to achieve knowledge utilization in prerequisite skills for being successful in the derivative concept. In general, both analysis and knowledge utilization are the two domains which are definitely required for the learning achievement of derivative concepts. The teaching should go beyond stressing the retrieval cognitive level in the settings in which derivative is teached.

Keywords: Derivative, Prerequisite Concepts for Derivative, Affective, Demographic, Retrieval, Comprehension, Analysis, Knowledge Utilization, Structural Equation Modeling (SEM)

ÖZ

ÜNİVERSİTE ÖĞRENCİLERİNİN TÜREV KONUSUNU KAVRAYIŞLARI ÜZERİNE BİR MODELLEME ÇALIŞMASI

Kula, Fulya

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Bu çalışmanın amacı, Türkiye'deki üniversite öğrencilerinin bilişsel düzeylerde ele alınan türev konusuna önkoşul olan bilgilerinin, öğrencilere ilişkin kimi özellikleri ile birlikte; türev konusundaki başarılarını nasıl etkilediğini belirlemektir. Çalışmada ele alınan bilişsel seviyeler; "bilgi edinimi", "bilgiyi kavrama", "bilgiyi çözümleme" ve "bilginin kullanımı"dır. Öğrencilere ilişkin özellikler ise; sosyoekonomik durum, matematiğe karşı motivasyon, matematik kaygısı, türev konusundaki öz yeterlik algısı, ve öğrencilerin demografik profilleridir.

Öğrencilere ilişkin özellikler, türeve önkoşul bilgilerdeki dört bilişsel seviye ve türev konusundaki dört bilişsel seviye arasındaki varsayılan iliskileri test etmek için yapısal denklem modelleme yöntemi kullanılmıştır. Örtük değişkenleri temsil eden gözlenebilen degiskenler, açıklayıcı faktör analizi ve doğrulayıcı faktör analizi uygulanarak tespit edilmistir.

Bu çalışmaya göre, türev konusunda başarı için, farklı bilişsel düzeyler ele alınmalıdır. Türev konusunun öğreniminde birçok bilişsel seviyenin önemli olduğu belirlenmiştir. Her alt grup önkoşul bilginn, türev ile farklı büyüklüklerde ilişkisi bulunmuştur. Önkoşul bilgilerden en önemli olanının bilginin kullanımı olduğu belirlenmiştir. Türev konusunun kavranması için mutlaka gerekli olan bilişsel önkoşul düzeyler, bilgiyi çözümleme ve bilginin kullanımıdır. Bu çalışmada öğrencilerin duyuşsal değişkenleri ve sosyoekonomik durumlarının bilişsel düzeylerle güçlü ilişkisi bulunmamıştır. Çalışmanın bulguları dogrultusunda ögretmenlere, program gelistiricilere, ve matematik egitimi arastırmacılarına kimi öneriler sunulmaktadır.

Anahtar Kelimeler: Türev, Türevin onkosul kavramları, Duyuşsal, Demografik, Bilgi Edinimi, Bilgiyi Kavrama, Bilgiyi Cozumleme, Bilginin Kullanımı, Yapısal Denklem Modellemesi

To my parents, Hülya Kula and M. Kemal Kula

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MNT	:	Marzano's New Taxonomy of Educational Objectives
MARS	:	Mathematics Anxiety Rating Scale
MARS-SV	:	Mathematics Anxiety Rating Scale – Short Version
SES	:	Socioeconomic Status
DPQ	:	Demographic Profile Questionnaire
ACQ	:	Affective Characteristics Questionnaire
DAT	:	Derivative Achievement Test
CGPA	:	Cumulative Grade Point Average
MMS	:	Mathematics Motivation Scale
DSS	:	Derivative Self-efficacy Scale
ASI	:	Approaches to Studying Inventory
CFA	:	Confirmatory Factor Analyses
SEM	:	Structural Equation Modeling
EFA	:	Exploratory Factor Analysis
MOTIV	:	Mathematics Motivation
TANX	:	Test Anxiety
SANX	:	Social Anxiety
SELF	:	Self-Efficacy in Derivative
PRET	:	Retrieval Cognitive Domain in prerequisite knowledge of Derivative
PCOMP	:	Comprehension Cognitive Domain in prerequisite knowledge of Derivative
PANLYS	:	Analysis Cognitive Domain in prerequisite knowledge of Derivative
PKU	:	Knowledge Utilization Cognitive Domain in prerequisite knowledge of Derivative
DRET	:	Retrieval Cognitive Domain in Derivative
DCOMP	:	Comprehension Cognitive Domain in Derivative
DANLYS	:	Analysis Cognitive Domain in Derivative
DKU	:	Knowledge Utilization Cognitive Domain in Derivative

CHAPTER 1

INTRODUCTION

Calculus is seen to be one of the great achievements of the human mind and has widespread applications in natural and applied sciences for which algebra alone is insufficient (Boyer, 1949). While in a respect, mathematics itself came into being with the development of calculus, the place of calculus in between the natural and humanistic sciences makes it a productive basis of higher education. Calculus constitutes a major part of modern mathematics education in the high school and university years. Particularly calculus focuses on functions, limits, derivatives, integrals and infinite series. The concepts and principles learnt in the calculus course are carried and used not only in the future courses but also in various situations in life such as heat, light, acoustics, reaction rates, radioactive decay , and astronomy. It is a fundamental course for engineering and science students. Calculus and especially derivative, are used in a variety of concepts by various disciplines like physics, engineering, chemistry and applications of business.

Modern scientific view has been shaped from calculus concepts, mainly derivative which is the core of calculus. Derivative lies at the foundation of the scientific world view (Bressoud, 1992). Providing a basis for the modern sciences, derivative constitutes an important factor for the development of many branches of science. Without regard to specific details, derivative can be thought of as how much one quantity is changing in reaction to changes in some other quantity. The concept has various definitions like; the limit of the difference quotient, the slope of the tangent line, instantaneous rate of change, or velocity (Boyer, 1949).

There is considerable variation in the applications of derivative not only in academic life but also in real life. Rate of change in position, velocity, or temperature are the simplest examples of the real life applications. Derivative requires high level of understanding and hence it is taught in late high school and early university years. Mastery in derivative is profitable for the students all along their lives. Because of the above mentioned considerable factors, the teaching of derivative is very important in the high school and university.

Studies dealing with the achievement of derivative in both high school and university levels exist in the literature. These studies make it clear that derivative is a relatively abstract and difficult concept of mathematics which builds upon considerable prior knowledge (e.g. Kieran, 1992; Orton, 1983). Previously acquired concepts considerably impact on students' achievement of calculus, especially the derivative concept (Kieran, 1992; Orton, 1983; White & Mitchelmore, 1996). Vast amount of literature supports the fact that students' background knowledge of the prerequisite concepts affects their understanding of derivative concept (Amit & Vinner, 1990; Asiala, Cottrill, Dubinsky, & Schwingendorf, 1997; Leinhardt, Zaslavsky, & Stein, 1990; Orton, 1983). Additionally the existence of multiple definitions in the derivative concept displays the vital necessity of the prior knowledge for the learning of the derivative. These mentioned prior concepts are algebra, functions, limits and tangency (Ferrini-Mundy & Lauten, 1993; Habre & Abboud, 2006; Heid, 1988; Pillay, 2008; Tall, 1993; Vinner & Dreyfus, 1989; Zandieh, 2000) and are most likely to impact on the achievement of derivative. These concepts will be referred to as prerequisite knowledge/concepts hereafter.

The involvement of the prior knowledge in the derivative concept can be exemplified in various ways. For instance, when calculating the derivative, making operations on the limit definition of derivative, the use of symbols, the infinitesimal concept embedded in derivative, and the notion of the instantaneous rate of change require the effective use of algebra (Hauger, 1998; Orton, 1983). Algebraic knowledge is also used in the algebraic procedures and symbolic representations of the derivative (Pillay, 2008). On the other hand, functions have direct impact on students' understanding of derivative (Ferrini-Mundy & Lauten, 1993). Students necessarily need the command of the knowledge of function when taking the derivative of a function, the use of continuity and differentiability concepts. Various types of functions are used in derivative widely in their graphs and representations (Eisenberg, 1991; Tall & Vinner, 1981). Besides the derivative is defined as the limit of secant lines forming the tangent line at a point of a curve. The limit concept is not only used in this definition but beyond, the derivative is formally defined via limits on functions and thus this concept is evidently embedded in derivative. Consequently it is clearly determined in the literature that students' difficulties in limits cause their difficulties in derivative (Artigue, 1991; Tall, 1986). Last but not least, knowledge of tangency has a significant role on the understanding of derivative and its graphical interpretations (Feerini-Mundy & Lauten, 1993; Orton, 1983). It has been noted that strong background in these prerequisite concepts foster the learning and understanding the derivative (Ferrini-Mundy & Lauten, 1994; Vihonainen, 2006; Orton, 1983; Biza, Christou, & Zachariades, 2006). In this regard, to achieve a good understanding of the derivative, students need to make the connection among these prerequisite concepts of derivative and use all coherently.

Students' low achievements in derivative have been proved to be a universal case by the previous research studies (Dunham & Osborne, 1991; Ferrini-Mundy & Graham, 1994; Orton, 1983; Selden, Mason, & Selden, 1989; Viholainen, 2006). However the connection of the prerequisite concepts and the derivative is insistently a problematic case for students, also in the undergraduate level (Pillay, 2008). Students who take calculus course, even in the university level have difficulties to cope with this connections (Parameswaran, 2007).

For the achievement of derivative, there is more than students' prerequisite knowledge to consider. Academic success in any subject matter requires a good command in cognitive skills as well as the subject matter. The understanding of the multiple definitions of derivative and the use of them in conjunction, require a rich and robust conceptual understanding which designate the cognitive dimension into action. For the efficient and coherent use of previously learnt concepts, students also need actively employed cognitive processes. Consequently, students' cognitive processes clearly appear in the achievement of derivatives which was also found to be valid by the literature (Orton, 1980; Viholainen, 2006).

On the other hand, students have difficulties to connect the multiple definitions (Ferrini-Mundy & Graham, 1994) and multiple representations (Dunham & Osborne, 1991) of the derivative. Research studies conducted about the use of multiple representations indicated that students have considerable difficulties in connecting different representations effectively and generally have mastery in only one representation (Habre & Abboud, 2006; Morgan, 1990; Ferrini-Mundy & Lauten, 1994). These primitive derivative conceptions demonstrate not only students' lack of prerequisite knowledge, but also their cognitive deficiencies. The necessity and importance of prerequisite concepts and the cognitive skills in derivative achievement are focused either separately in the literature or all the prerequisite concepts were not investigated at one specific study.

There exist frameworks examining students' cognitions of mathematics in higher education in the literature. For instance, the idea of *procedural* versus *conceptual knowledge* focuses on distinguishing respectively the connected web of knowledge and knowledge of algorithms or procedures. The ideas of *concept definition* and *concept image* are other constructs to denote the formal definition of a concept and the total cognitive structure associated with a mathematical concept respectively (Tall & Vinner, 1981). Besides, *APOS theory* developed by Dubinsky and collegues addresses the cognitive construction of calculus concepts in students' thinking (Dubinsky & McDonald, 2001). These frameworks have been used to analyze students' mathematical understanding in higher education. These various frameworks or models which evaluate students' cognition, validate the existence and importance of various cognitive skills in the derivative. However the cognitive processes were not considered in adequate detail, hence none comply with the current study.

For a good command of the derivative, the necessary cognitive skills are carrying out the known procedures of the derivative, inferring new generalizations from the known information and applying knowledge in specific situations. Moreover, identifying the differences of and making the connections among the multiple definitions of the derivative is necessary for derivative applications. Besides, as required in the minimum-maximum or optimization problems, students need to apply and use the derivative knowledge in specific situations with limiting conditions. While the cognitive skills mentioned above exactly cohere to the derivative concept, they also fit and become clear in the new taxonomy of educational objectives asserted by Marzano and Kendall (2007). Marzano's New Taxonomy (MNT) covers the cognitive skills in four levels named as; retrieval, comprehension, analysis, and knowledge utilization (Marzano & Kendall, 2008).

Consequently, for achieving the content and the cognitive processes in derivative, students need particular competencies. These require mastery in cognitive skills with the efficient use of prerequisite concepts. Hence it appears as, there is a possibility to understand what sort of skills are required before teaching the derivative concept. However in the literature there is no specific study attempting to reveal these interrelationships in a way to consider the prerequisite knowledge as well.

1.1 Purpose of the Study

The impacts of some student related factors on students' achievement levels were studied in mathematics education along the literature. Success in the performance of calculus can be attributed to the dynamic and complex interaction between cognitive skills, prerequisite knowledge and student related factors. Researchers have consistently found that some student related factors are significant for students' achievement. Especially the importance and significant effect of motivation (Chanmin, 2007; Yee, 2010), anxiety (Fenneman, 1973; Webb, 1971), self-efficacy (Hall & Ponton, 2005; Pajares & Miller, 1995) and socioeconomic status (Reyes & Stanic, 1988; Tate, 1997) on achievement is evident by the literature. Therefore, there is a need to analyze derivative related factors of the students by considering all of the variables mentioned above. Thus in the present study, a linear structural model was tested as indicated in Figure 1.1.

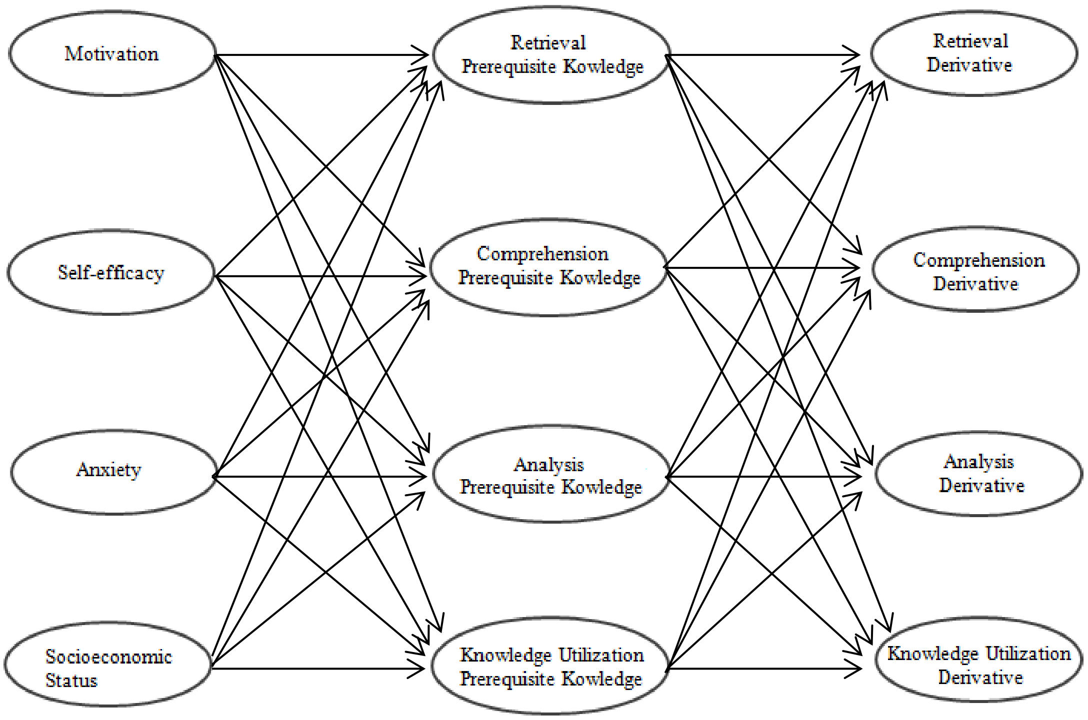

Figure 1.1 Hypothesized Derivative Model

As it is seen in Figure 1.1 there are three groups of variables. In the first group students' affective variables were considered as latent variables, such as motivation, self-efficacy, axiety, and socioeconomic status. In the second group there are latent variables representing retrieval, comprehension, analysis, and knowledge utilization cognitive levels of achievement in prerequisite knowledge of derivative. Hence the prerequisite knowledge is defined by four cognitive groups. Finally the third group represents the dependent variables as defined in latent variables. These are basically achievement in derivative as adressed with retrieval, comprehension, analysis, and knowledge utilization cognitive levels.

As it is seen from the model in Figure 1.1, all the direct relations of the first group to the second group are tested. Similarly, all the relations from the second group to the third group are tested. Naturally relations of the first group of variables to the third group, which are the dependent variables of the present study are evaluated as indirect relations in the analysis section. The latent varibles seen in the model were all constituted empirically. This is going to be explained in the result section as well. In sum, the model indicated in Figure 1.1 tests the impact of prerequisite knowledge in derivative concept on the achievement in derivative related learning outcomes, as defined by various latent variables, such as retrieval, comprehension, analysis, and knowledge utilization cognitive levels. However, at the same time the model also includes the affective variables of the students. These variables were basically used as control variables, since the relations of motivation, self-efficacy, anxiety, and socioeconomic status to derivative achievement are consistenly found out by previous research studies. As it is seen in the hypothesized model, achievement of the students in derivative was considered as a multidimensional variable. This is also true for the achievement of the students in prerequisite knowledge. In the present study achievement of students in these two groups of variables are treated as a multidimensional variables, based on the MNT. In this model students' learning outcomes are defined in the cognitive levels of retrieval, comprehension, analysis, and knowledge utilization. The metacognitive system and self-system are not in the cognitive system of MNT and also these systems are not included in the present study. It is expected that this analytic treatment of the achievement variables would help to understand students' achievement in derivative in a more detailed fashion.

1.2 Significance of the Study

Students' lack of conceptual understanding and low achievement of the derivative concept is reported in various studies. In addition, it seems that the prerequisite knowledge required for derivative can be explored before its teaching. However there is no specific study attempting to understand these interrelations in a way to consider the cognitive skills and student related factors. The current study considers the cognitive levels and includes the affective variables as well. Hence the structure among the variables will be explored in order to better teach the derivative.

Several studies have been conducted to explain the difficulties of students in the derivative concept. Some of these studies include the relationships between derivative and some specific prerequisite knowledge of derivative like algebra or limits alone, which disregard the discrimination of cognitive skills. There are not enough research studies concerning derivative performance of university students in line with cognitive skills. The findings of the current study will provide an insight for the relationships among cognitive skills in prerequisite knowledge, derivative within university level calculus in Turkey.

Furthermore, the current research on derivatives delineates the construct within prerequisite knowledge in the line of its regulation of cognitive skills on students' performance taking the student related factors

CHAPTER 2

REVIEW OF RELATED LITERATURE

This chapter involves the review of the related literature concerning the derivative concept, the prerequisite knowledge for the derivative concept, the cognitive skills, and the affective variables. The interrelations among the prerequisite knowledge of the derivative, knowledge for derivative and cognitive skills are also mentioned.

2.1 The Concept of Derivative

The average velocity over a time interval is defined as the ratio of change when science is concerned with a time interval. In the case of instantaneous velocity, the distance and time intervals are zero. However there is no question of speaking of the instantaneous velocity because the laws of science are formulated by induction on the basis of the evidence of the senses. Instantaneous velocity was also rejected by Aristotle with the belief that things beyond the power of comprehension are beyond the realm of reality (Boyer, 1949). In the sense of a scientific observation, we cannot speak of instantaneous motion or velocity. However this difficulty of representing the instantaneous velocity is resolved by the introduction of derivative which is based on the idea of the limit of infinite sequences. The derivative is thus defined not in terms of the ordinary processes of algebra, but by an extension of these processes to include the limit concept on an infinite sequence.

Historically talking, the basis of the concepts leading to the derivative was first found in geometry. However, calculus has been gradually emancipated from geometry and by means of the definitions of derivative it has been made dependent on the notion of natural numbers. It was the nineteenth century when the basic concept of derivative was carefully defined (Boyer, 1949, pg. 59).

As seen from the historical development, the concept of derivative developed over a considerable time of two thousand years. The reason of this time taking evolution is the structure of the concept including the ideas of instantaneous velocity and limits. Derivative has multiple definitions and interpretations. These include the use of the ideas of velocity, instantaneous velocity, number concepts, infinitesimal numbers, and rate of change, functions, limits and geometry. Hence the mathematical concepts which constitute basis for the derivative can be examined under four topics; algebra, functions, limits, and tangency. The way these prerequisite concepts are included in the derivative will individually be examined in the following section.

2.2 The Prerequisite Concepts Embedded in Derivative

Algebra takes place in derivative concept as a prerequisite knowledge in many forms. Derivative is defined as the instantaneous rate of change in which the rate of change concept is embedded. Hence a strong understanding of ratio and proportion concepts is necessary for the derivative knowledge. In the calculation process of derivative with the limit definition, algebraic rules have to be used. Moreover, the symbols being used in the derivative, e.g. the symbols of differentiation require the complete understanding of the meanings of these symbols. Additionally, to understand the derivative concept fully, the limiting process in the derivative requires a good command of not only numbers but also the infinitesimal numbers; i.e. numbers that are so small that they cannot be distinguished from zero by any available means.

Besides derivative is an operation on functions and hence includes the function concept distinctly. On the other hand, the derivative of a function forms another function. The concept of variables within the function concept; dependent and independent variables, has to be used when solving problems of the derivative. Additionally the idea of composite function is used fairly in the derivative.

The multiple definitions of the derivative include the limit concept. Derivative is the limit of the ratio of change. The vital roles of the limit concept in the derivative appear also in the sequence of secant lines approaching to the tangent line. This also explains the tangency concept embedded in the derivative.

The research literature of the derivative in most cases relates directly to the background matters (Ferrini-Mundy & Graham, 1991). The importance of the basic concepts underlying the calculus concepts and hence the derivative is emphasized by the previous research (Orton, 1983; Asiala, et al., 1997; Kieran, 1992; Orton, 1983; White & Mitchelmore, 1996). Moreover the necessity of a good command of these basic concepts is also stressed (Orton, 1983). Students' difficulties with the concepts of algebra (Orton, 1984), limit (Cornu, 1991; Heid, 1988), tangency (Vinner, 1982; Tall 1987), and functions (Dreyfus & Eisenberg, 1983; Even, 1993; Vinner, 1983; Vinner & Dreyfus, 1989) are well documented. This implies the importance of students' working knowledge and an understanding of the sufficient prerequisite knowledge. In the following section, these prerequisite concepts of derivative will be analyzed through the literature.

2.3 Studies of the Prerequisite Concepts in the Literature

2.3.1 Algebra

Studies that have examined the prerequisite concepts along with the literature have supportive findings that acquisition of these concepts is crucial for students' derivative achievement. As an example, it was determined that lack of mastery in algebraic fluency results in the failure in reaching the result of the derivative taking process (e.g., Habre & Abboud, 2006; Orton, 1983, Pillay, 2008). This fact is valid also in the university level (Pillay, 2008).

Lack of fluency in carrying out algebraic procedures, such as applying distributive law to expand the brackets and simplifying algebraic fractions, featured very often among university level students (Pillay, 2008). Moreover majority of the students taking calculus course were found not to be able to solve simple inequalities (Habre & Abboud, 2006) and simple kind of algebra problems (Clement, 1982). Researchers conclude that due to their poor performance, large numbers of students are in need of an algebra course prior to a calculus course. The emphasis of ratio and proportion ideas in the high school or pre-calculus levels is also recommended for the development of the understanding of the derivative (Ferrini-Mundy & Lauten, 1993). The reason of this fact is students' trouble in realizing the average rate of change as a ratio value (Orton, 1983) and understanding of the rate of change as closely connected to the average rate of change (Hauger, 1998). This procedure based concept of the rate of change becomes an obstacle for students to deepen their understanding of the connection between average rate of change and the instantaneous rate of change. This obstacle occurs because it is difficult to relate this procedure with the instantaneous rate of change over infinitesimal intervals (Hauger, 1998). It was also determined that a relational understanding of average rate of change supports students' understanding of the derivative (Thompson, 1994).

Moreover, the procedures followed in algebra affect students' derivative performance. For instance students operate the symbols of the derivative concept as if they do that of algebra (Morgan, 1990). The reason is students' knowledge in algebra which is less conceptual and more procedural. The studies indicate that having a strong algebraic background, students can grasp the procedural aspects of derivative, while the conceptual understanding presents more difficulty (Ferrini-Mundy & Lauten, 1994). Another result of this fact is that most students' understanding of derivative is typically algebraic (Tall, 1991; Vinner, 1989) which prevents the connection of different definitions and interpretations of derivative. There is a large gap between students' symbolic understanding of algebraic manipulations and graphical realizations of the derivative concept (Ferrini-Mundy & Graham, 1994). Students in the university level have many difficulties to connect symbolic and graphical representations (Dunham & Osborne, 1991). This fact is also supportive for the weak procedural knowledge of algebra generating an obstacle for the derivative achievement.

2.3.2 Functions

Students' understanding of the function concept was necessarily taken into account when their thinking of the derivative was examined. Previous research identified that the ways in which students understand functions are related directly to the ways in which they understand derivatives (Ferrini-Mundy & Lauten, 1993). Students' thinking about the co-varying nature of the functions (that one variable of the function vary dependent to the other variable), derivative of a function as a separate function and the algebraic representation of the derivative function is closely related to their failure of the derivative concept.

Many calculus students do not bring with them a sufficiently strong function concept (Asiala, et al., 1997). In the literature there appear student misconceptions of functions which were proven to affect their derivative conceptions. There is a tendency to think that all functions are linear or show a pattern. Another general misconception is that, students think that all functions are one-to-one with smooth and continuous graphs. Students think that the formulas of functions need to represent an algebraic formula and necessarily include the variable x (Becker, 1991). These misconceptions hinder students' procedural understanding of the derivative being an operation on functions. Grounded with their thinking of a function represented with only one equation (Eisenberg, 1991), students tend to think that a piecewise function is not differentiable at the point where the equation is changed as it has two derivative values at that point (Ferrini-Mundy & Graham, 1994).

It is also reported that when students deal with the function concept, they rely predominantly on the use of algebraic formulas (Breidenbach, Dubinsky, Hawks, & Nichols, 1992; Dreyfus & Eisenberg, 1983; Tall & Vinner, 1981; Vinner & Dreyfus, 1989). Supporting this fact, when determining the differentiability of a graph of a function, an important factor is determined as the preference of algebraic representations. Students' tendency to find algebraic representations of a function is related to their thinking about differentiability (Ferrini-Mundy & Graham, 1994). Additionally students think of the function concepts in only a symbolic representational mode (Eisenberg, 1991). The graphic relationship between a function and its derivative is a facet to have a conceptual understanding of the derivative. Even though students are taught and aware of this relationship, regardless of the context they have a tendency to assume that the behavior or appearance of a function resembles its derivative (Nemirovsky & Rubin, 1992). Students' function conceptions are depicted to affect the derivative knowledge directly as the functions are in the heart of derivative knowledge.

A finding in the study by Thompson (1994) was that, students think of a function having two sides separated by the equal sign. This sort of understanding may lead students to consider the function as one thing that changes (Thompson, 1994) which may hinder the understanding of the composite function. This explains students' general confusions when taking the derivative of the composite function. Originating from their insufficient function conception, even the students who can correctly calculate the first and second derivatives of a function have difficulties in distinguishing the difference in between. This difficulty is one of the results of students' superficial concept of the function concept as varying on only one variable, namely x (Santos & Thomas, 2003).

Moreover it was determined by the literature that vast majority of the students do not understand the *variables* at a conceptual level (Eisenberg, 1991; Wagner, 1981). White & Mitchelmore (1996) depicted that university students have a very elemental understanding of the *variable*. Results of the mentioned study demonstrated that instead of the quantities to be related, students treated variables as symbols to be manipulated. Students' concept of a variable was limited with algebraic symbols. Without any regard to the contextual meaning, students learn to operate on symbols (White & Mitchelmore, 1996). This procedural level of knowledge of variables, necessarily affect students' derivative proficiency, as variables are used in derivative in wide range.

2.3.3 Limits

It is well documented across several countries that, students have same persistent errors and difficulties when they deal with the limit concept (Selden & Selden, 1992), particularly the limiting process subsistent in the derivative (e.g. Cornu, 1991; Heid, 1988; Orton, 1983; Zandieh, 2000). For understanding the limiting process within the derivative some representation of it should be used, rather than ony using the algorithm for the limit of the difference quotient. It is found that the derivative expression as a limit in a graphical context was poorly understood among the students (Artigue, 1991).

The precise formal definition of the limit concept is complex and counter-intuitive. On the other hand, studies indicate that students view the limits as an approximation process (Parameswaran, 2007) and confuse the limit and bound ideas (Tall, 1993). The derivative is mathematically defined via limits and hence students' conceptions weaken their understanding of the derivative concept. Studies indicate that students' understandings of limit are related to their difficulties in understanding the tangent line, which is the derivative obtained as the limit of secant lines.

The most popular understanding of the limit among students is that a sequence may approach to its limit but never get the limit value (Tall & Vinner, 1981). Students also conclude that the sequence of secant lines approaching to a tangent line could never get to the tangent line with the same logic (Orton, 1983; Tall & Vinner, 1981) being parallel to their conception of the limiting value never being approached (Juter, 2005). These kinds of understanding hinder students' understanding of the graphical interpretation of derivative as the limiting process to obtain the tangent line from many secant lines (Orton, 1983; Tall, 1986). As seen, the multiple prerequisite concepts within derivative interact. This fact itself shows the necessity of a strong understanding of these concepts.

2.3.4 Tangency

Students were found to have little understanding in the graphical interpretations of the derivative while their routine performance on differentiation items was adequate (Orton, 1983). Despite the success in computing the derivatives, students have limited abilities to work with geometric or physical representations of the derivative (Ferrini-Mundy & Lauten, 1993). When students' ideas of graphical interpretation of the derivative was addressed, research studies found out that students' previous understanding of tangent lines are related closely to their thinking of the tangent line to a graph of a function.

Many students think that the tangent line to a curve should only intersect the curve in the tangency point (Biza, Christou, & Zachariades, 2006). Also the possibility of drawing more than one tangent line at a point and the existence of the tangent line at a cusp point is other student misconceptions (Biza, Christou, & Zachariades, 2006). Computing slopes from graphs is generally difficult for students (Leinhardt, Zaslavsky, & Stein, 1990). There are also students with no idea how to express the meaning of the tangent and derivative in their own words (Ismail, 1993). Students' difficulties with graphical interpretations of the derivative occur not only with complicated curves, but even with straight lines (Orton, 1983). Most students fail to see how the secant lines relate to the tangent line, and hold the belief that the derivative of the function is actually the equation of the tangent line (Ferrini-Mundy & Lauten, 1993). Additionally, some students think of the derivative of a function as same of the equation for the tangent line to the graph of the function at a given point (Amit & Vinner, 1990).

The literature about the prerequisite knowledge affecting the learning of derivative was mentioned above. The previous research studies showed the necessity and importance of a strong command of these prerequisite concepts; namely algebra, functions, limits and tangency. It was made clear that the absence of such command in the mentioned concepts results in the weak derivative conceptions in high school and university levels.

There is vast amount of literature about the prerequisite concepts embedded in the derivative. These studies made it clear that the prerequisite concepts have high importance to be perceived by students for a better understanding of the derivative. However in the derivative concept, most students have many consistent difficulties. The origins of these difficulties are found to lay in the lack of prerequisite knowledge. Moreover the studies showed that, a more conceptual understanding of these prerequisite concepts is necessary for a strong understanding of derivative. The previous research showed the necessity of presence and strength of the prerequisite knowledge. However the question that in which ways these prerequisite concepts affect the acquisition of derivative was left unanswered.

Even students' strong procedural knowledge is deficient for a good command of derivative (Ferrini-Mundy & Lauten, 1994). While the reason of this fact is seen as the obligatory connections of multiple definitions and interpretations of the derivative, the scientific results show that other components must be considered while examining the prerequisite knowledge within derivative. Literature shows us that the poor derivative conceptions of students with or without a strong procedural prerequisite knowledge points out the vital existence of cognitive skills within the derivative. In the literature, we come across various questions and solution suggestions about the difficulties in prerequisite knowledge for the derivative concept. However while the importance of these was made clear along with the literature, we cannot encounter satisfactory answers showing the interrelations between the prerequisite knowledge and the derivative addressing cognitive skills as well.

2.4 Cognitive Skills and the Derivative

The purpose of the mathematics educators is to provide experiences in a cognitive manner which develop the ideas of the calculus, for the learner to both know and understand. The research studies showed that even students who have good performance in computing routine aspects of derivatives, have the tendency to resort to guessing when encountered with problem solving (Morgan, 1990; Orton, 1983). Even the most successful students, who possess adequate knowledge base of relevant calculus skills, may not solve some new type of calculus problems with even non-complex solutions (Selden, Selden, & Mason, 1994). Students’ good performance of computation skills do not follow their abilities to work with multiple representations or non-routine problems about the derivative (Orton, 1983). Hence it is obvious that mastery in the derivative concept requires more than performing procedures by rote, which follows the existence of cognitive processes.

Connections and the translation ability between the representations of derivative are significant to learn the concept (Kendal & Stacey, 2000; Santos & Thomas, 2003). The use of and translation among multiple representations is noteworthy in the derivative concept and has its place in the literature. The connections and transformations among multiple representations also indicate cognitive skills in the derivative. Students' proven computational proficiency, nevertheless their lack of performance on the connection or translation among multiple representations and their lack of performance about the problems about the derivative shows students need cognitive processes in the acquisition of the derivative.

2.5 Cognitive Processes Inherent in Derivative

Obviously, the learning of derivative concept involves the mental processes for acquiring and retaining and besides employing knowledge. In the acquisition of derivative concept, there appear the processes of transferring the knowledge and identifying critical or defining features of knowledge. The connection among various representations of the derivative requires this cognitive skill. The literature specifies students' understanding of derivative as limited to algebraic and visual (Tall, 1991; Vinner, 1989) however students have difficulties in the connection among various representations of derivative (Artigue, 1991; Dunham & Osborne, 1991; Ferrini-Mundy & Graham, 1994).

Moreover, the derivative actually requires the reasoned extension of knowledge and generation of new knowledge not already possessed by the individual. An example may be given as drawing the graph of a function given with the algebraic form with the help of derivatives. However, according to the literature students' have many difficulties in these skills (Habre & Abboud, 2006). Additionally in the problem solving situations and the interrelated use of multiple representations of the derivative, the application and usage of knowledge in specific tasks appear. Hence the derivative requires to be taken into account with the cognitive dimension as well.

Consequently, there is always a prerequisite subject matter dimension and the cognitive processes as well in the acquisition of the derivative concept. Thereby, achievement in the derivative concept is the function of cognitive processes (Tsamir, Rasslan, & Dreyfus, 2006; Viholainen, 2008) and the prerequisite subject matter areas (Aspinwall, Shaw, & Presmeg, 1997; Orton, 1983; Viholainen, 2008) among the university students. The subject matter determined might reflect different cognitive processes to achieve the important cognitive skills in the derivative concept. The important structure at this point is the definition of the acquisition of derivative concept in terms of prerequisite subject matter aspects and cognitive processes. In the present study, derivative concept attainment is defined as students' ability to use the mentioned necessary prerequisite subject matter with the cognitive skills.

The studies addressing the learning of the derivative generally focuses on procedural versus conceptual understanding, multiple representations or computer applications. While few studies address calculus in line with the cognitive skills, studies which cover the derivative concept with the cognitive dimension are rare. These studies defined obtaining cognitive dimension in calculus as the learner both knowing and understanding ideas of the calculus. Some studies did not use the cognitive dimension in calculus as cognitive processes into account, rather the desired goal was taken as the relational understanding in the sense of Skemp (Skemp, 1976), with the concepts fitting together coherently, mutually supportive manner (Tall, 1985). Hence the cognitive processes were interpreted in terms of the theories in mathematics education in these few studies. Some of these studies focused on the use of computers in teaching calculus. The gain of using computers was the possibility of providing the cognitive learning in calculus without the prerequisite concepts. Hence, the importance of the prerequisite concepts is evident by the literature. It is crucial to obtain a strong command of them for the substantial derivative knowledge. Moreover computer approach was found to help students gain a cognitive understanding of concepts that are mathematically difficult (Tall, 1985). This cognitive understanding referred to relational understanding of Skemp but the way cognitive skills appear in the learning of the derivative concept was not profoundly examined.

2.6 Cognitive Skills in the Literature

With the developments in cognitive science, appeared again the need for thinking the instructional approaches regarding teaching. According to the behaviorist point of view, learning a complex task is associated with breaking it into the suitable number of steps and repetition of each step till the level of mastery. The behaviorist approach viewed the cognitive processes as packets of information to be acquired piecewise.

The cognitive approach emphasizes the cognitive skill as a holistic capability (Royer, Cisero, & Carlo, 1993). While there are other taxonomies, in this study the focus is on the taxonomies of the cognitive approach. Moreover, taxonomies of educational objectives are tools used to lead instructors in planning and assessing the curricular activities defined with the cognitive processes basically in K-12 education. In 1970's the taxonomy of educational objectives asserted by Bloom and colleagues (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956; Bloom, Hastings, & Madaus, 1971) was considered as a pioneer in categorizing student learning outcomes in cognitive domains. This framework reflects the influence of behaviorism that characterized educational theory in the 1950's. It enlarged the notion of learning and thinking from a simple model to the one that was more multi-faceted in its nature.

Bloom's taxonomy became widely known and cited as the researchers recognized its use. One of the most common uses of the taxonomy has been to categorize curricular objectives and test items. The more explicitly the goals are stated, the more precisely the instruction can be evaluated. Because of this reason Bloom's taxonomy evidenced a powerful tool for objective-based evaluation (Marzano, 2001).

The mentioned taxonomy expanded the learning concept from a one-dimensional behaviorist model to the one that was multidimensional constructivist nature. Yet, with the extensive use of the taxonomy, the research conducted revealed empirical inconsistencies in its structure.

Bloom's taxonomy was criticized mostly for oversimplifying the nature of thought and its relationships to learning (Furst, 1994). From logical or empirical perspectives, Bloom's taxonomy's hierarchical structure did not hold well. For the detailed analysis of the mentioned inconsistencies see Hauenstein (Hauenstein, 1998). All these criticisms led revisions in Bloom's taxonomy to advance learning in cognitive psychology (Anderson & Krathwohl, 2001).

Following Bloom's taxonomy, researchers had attempts to improve the taxonomy or to devise for easier use (e.g. Anderson, et al., 2001). From the development of Bloom's taxonomy, several other taxonomies have been developed to assist in identifying the cognitive process levels. Like Bloom's taxonomy, several frameworks developed are configured one-dimensional (Gerlach & Sullivan, 1967; Ausubel & Robinson, 1969; Gagne & Briggs, 1979; Hauenstein, 1998) and others multidimensional (DeBlock, 1972; Marzano, 1992; Merrill, 1994). In 2001 a revision of Bloom's taxonomy was generated (Anderson et al., 2001). The revision mentions two other dimensions to be considered: the cognitive process dimension and the knowledge dimension. A more recent revision of Bloom's taxonomy was published by Marzano and Kendall (2007), in which they explain that the two dimensions to consider for the new taxonomy are the levels of processing and the domains of knowledge. This process developed into a extremely many taxonomies (Anderson et al, Ausubel & Robinson, 1969; Gagne, 1972; Gerlach & Sullivan, 1967; Haladyna, 1997; Hauenstein, 1998; Merril, 1994; Quellmalz, 1987; Reigluth & Moore, 1999; Stahl, 1979; Tomei 2005) which show more or less the same pattern of cognitive processes with Bloom's classification.

2.6.1 Bloom's and Following Taxonomies

As an attempt of the student outcome from instruction, Bloom's taxonomy of educational objectives defined six main categories in the cognitive domain. Bloom's taxonomy outlines six cognitive process categories each of which has broken down into subcategories: *Knowledge*, *Comprehension*, *Application*, *Analysis*, *Synthesis*, and *Evaluation*. The *knowledge* category emphasized the remembering either by recognition or memorizing of phenomena. The *comprehension* category represents the lowest level of understanding of information. In the *application* category, abstractions are used in specific and concrete circumstances. The *analysis* category breaks down information into its constituent parts so that the relationship among these parts of an idea is made clear. In the *synthesis* category, the parts from different sources are put together in order to form a whole and to produce unique patterns. The final category; *evaluation* involves the combination of all the other behaviors.

The revised Bloom's taxonomy involves six categories: *Remember*, *Understand*, *Apply*, *Analyze*, *Evaluate*, and *Create* (Anderson et al., 2001). Within this taxonomy, three categories were renamed and two were interchanged in switching the categories to verb form for the purpose of including the uses of instructional objectives. In this taxonomy the category of *Knowledge* was renamed as *Remember* and the category of *Comprehension* was renamed as *Understand*. The name *Understand* was used because it is a widespread synonym for the term *comprehending*. *Application*, *Analysis*, and *Evaluation* were retained as the verb forms *Apply*, *Analyze*, and *Evaluate*. *Synthesis* changed places with *Evaluation* and renamed as *Create*. The reason was the hierarchical nature of cognitive categories (Krathwohl, 2002).

Other taxonomies developed had a lot in common with Bloom's taxonomy in terms of cognitive dimension (e.g. Quellmalz, 1987, Gerlach & Sullivan, 1967; Stahl & Murphy, 1981; Merrill, 1994; Haladyna, 1997; Williams, 1977). The main similarity of all these taxonomies was in defining the cognitive domains similarly however name them with different action words. Another common factor of these frameworks is that all necessarily include main domains which may be defined with the action words of remembering, understanding, analyzing and problem solving in common from these frameworks. The distinctive definition of these four domains can be met in the taxonomy asserted by Marzano and colleagues (2008).

The suitable taxonomy for the purpose of the current study among the existing taxonomies was investigated (e.g., Marzano & Kendall (2007), Anderson et. al (2001), Haladyna (1997), Biggs & Collis (1982), Hannah & Michaelis (1977), Bloom (1956)). The main criteria for selecting the taxonomy was to make a clear division between the cognitive processes and the knowledge included in the problem solving and to involve the problem-solving process in the cognitive list process. Problem solving cognitive domain is defined in the knowledge utilization category which includes application or usage of knowledge in specific situations. From many of these mentioned aspects, the taxonomy Marzano and Kendall (2007) is used throughout the current study.

2.6.2 Marzano's New Taxonomy of Educational Objectives

The taxonomy developed by Marzano and his colleagues which describes the higher level thinking (Marzano, 1992; Marzano et al., 1988; Marzano, Pickering, & McTighe, 1993) has achieved much recognition. This taxonomy aims to assess educational objectives and is designed as a replacement for Bloom et al. (1956)'s taxonomy. Marzano's New Taxonomy (MNT) (Marzano, 2001; Marzano and Kendall, 2007) is based on a model of human thinking. This taxonomy is constructed both to describe phenomena and to be able to foresee outcomes. Additionally, including the meta-cognitive aspects, the taxonomy extends the hierarchy of mental processing. Hence it provides a system that includes the levels of self-awareness of the student. Briefly, the New Taxonomy is a two dimensional model which includes six levels of cognitive processes for one dimension and three domains of knowledge for the next dimension. The six levels themselves fall into three main categories; Self-system, Meta-Cognitive System, and Cognitive System based on the levels of student self awareness. These levels are as follows:

Level 6: Self-System

Level 5: Meta-Cognitive System

Level 4: Knowledge Utilization (*Cognitive System*)

Level 3: Analysis (*Cognitive System*)

Level 2: Comprehension (*Cognitive System*)

Level 1: Retrieval (*Cognitive System*)

The Level 6 is the Self-System. This level includes a network of interconnected beliefs, attitudes and expectations which are involved in making conclusions to engage in a new j. The motivation to complete the goal is determined at this level. Once the decision to engage in a new task is made, the Meta-Cognitive System (Level 5) is activated. At this next level, the goals related to the new task are defined and the strategies for accomplishing these goals are developed. Lastly, the Cognitive System, which is from Level 1 to Level 4, is concerned with the processing of the knowledge effectively, like classifying, making inferences, organizing ideas and executing operations.

For the purpose of this study, the restriction will be conducted to the four cognitive levels. Besides the meta-cognitive aspects will not be included in the taxonomy of the current study. Hence at a later stage it may be extended to include Level 5 and Level 6, as the Levels 5 and 6 are seen important for studies of mathematics learning and teaching. However, focusing on the cognitive aspects of university students' learning of the derivative is found more appropriate for the current study. Table 2.1 presents the outline stated in terms of the cognitive processes.

Table 2.1 A summary of Marzano's New Taxonomy of educational objectives

New Taxonomy Level	Operation	General Form of Objectives
Level 1: Retrieval	Recognizing	the process of validating correct statements about features of information without necessarily differentiating critical and non critical components
	Recalling	the processes of producing or recognizing basic knowledge without understanding the organization of the knowledge necessarily
	Executing	the process of carrying out a procedure without significant error without understanding why the procedure works and how
Level 2: Comprehension	Integrating	the processes of detecting the main structure of the knowledge and separating the critical and the non-critical elements from eachother
	Symbolizing	the process of building a correct symbolic image for the information
Level 3: Analysis	Matching	the process of finding similarities, differences and relationships which are related to the information
	Classifying	the process of identifying superordinate and subordinate categories related to the information

Table 2.1 (Continued)

	Analyzing errors	the process of identifying errors in the related knowledge
	Generalizing	the process of building new generalizations and/or principles from the available knowledge
	Specifying	the process of generating new applications or logical consequences from the available knowledge
Level 4: Knowledge Utilization	Decision Making	the process of making decisions in general or making decisions about the use of the knowledge
	Problem Solving	the process of accomplishing a goal or task with limiting conditions or obstacles
	Experimenting	the process of generating and testing hypotheses to understand phenomena
	Investigating	the process of generating and testing hypotheses about events in past, present and future while using well-constructed and logical arguments as evidences

Source: Marzano & Kendall (2007)

In the following section, the characteristics of levels 1 to 4 (the levels of the Cognitive System) of Marzano's New Taxonomy will be briefly discussed in the derivative context.

Level 1 (Retrieval): three sublevels are specified in this category: *recognizing*, *recalling* and *executing*. Both *recognizing* and *recalling* basically refer to remembering facts, concepts and equations related to the derivative or its prerequisite knowledge. The process of *executing* refers not to information but only the knowledge domain of mental procedures. This level exists in recognizing the multiple definitions of derivative. Additionally applying the prerequisite knowledge of derivative for the inferences of derivative knowledge is in retrieval cognitive process. Moreover, students who find the derivative of a function either with rules of differentiation or with the limit definition is also in this cognitive process. Forms of execution is required in most calculus textbooks.

Level 2 (Comprehension): two sublevels exist under this category: *integrating* and *symbolizing*. *Integrating* denotes identifying the critical versus non-critical characteristics of a situation. Applied to derivative or its prerequisite knowledge, in this process the student is required to extract the irrelevant details of the information and retain only the information needed to accomplish the goal. *Symbolizing,* refers to the translation between different representations of the derivative or its prerequisite information. This level stands out in derivative when for instance students identify the basic multiple definitons from eachother and are aware that all together specify the derivative. Also the use of symbols and various representations of derivative is in this level. This level differentiates from Level 1 clearly as in this level students do not simply perform of recall anymore but they have an understanding of the concept of derivative.

Level 3 (Analysis): the sublevels of this category are: *matching, classifying, analyzing errors, generalizing and specifying*. *Matching* is described as the process of identifying the important similarities and differences between the knowledge components. *Analyzing errors* as a sublevel of the cognitive process involves determining the reasonable extent of the information. *Generalizing* requires the students to conduct generalizations, while in *specifying* the students are required to predict outcomes and identify logical consequences of the information. For instance students who can classify the multiple definitions of derivative with the prerequisite knowledge being used are in this cognitive level. Besides the interpretation of the graphs of functions and graphs of derivative functions can be given examples for derivative that require the usage of this cognitive level.

Level 4 (Knowledge Utilization): four sublevel processes are specified in this category: *decision making, problem solving, experimenting and investigating. Decision making* includes identifying alternatives or the criteria that will be used to judge the value of each alternative. *Problem solving* includes both identifying obstacles or alternative and various ways to the goal and evaluating and executing the alternatives. The goal of problem solving is mainly the solution. Problem solving can involve both mental and physical steps. In the derivative concept, solving the optimization or maximum/minimum problems can be regarded as examples for this domain. *Experimenting* is about making predictions based on known or hypothesized principles, while investivating includes providing logical arguments for the confusion or contraversy using others' arguments. Either the minimum-maximum or optimization problems in derivative or drawing graphs of functions algebraically represented are examples of derivative that require students to be in the *knowledge utilization* process.

The distinctions of the four levels from eachother fit the structure of the derivative concept as mentioned earlier. Hence Marzano's New Taxonomy is seen appropriate to use for the current study. While Marzano's New Taxonomy is also appropriate for the applications in mathematics, there are inadequate number of studies which address mathematical subjects in line with the cognitive processes of this taxonomy. The reason for this poor usage of the taxonomy is the trend in research studies of derivative focusing on particular issues like representations or the use of computers.

2.7 Student Related Factors and Mathematics Achievement

Investigating how student related constructs influence the abilities of students in mathematics has always been a recommended research trend (Sternberg, 1996). Motivation, self-efficacy, anxiety and socioeconomic status are among the affective and demographic constructs in relation to mathematics achievement relevant to the current study. These constructs are considered as essential for achievement in mathematics.

2.7.1 Motivation

The concept of motivation has been referred by several terms in the literature, like student motivation or academic motivation (Winn, Harley, Wilcox, & Pemberton, 2006; Winn, 2002), teachers' motivation (Good & Brophy, 1997), and social motivation (Winn et. al, 2006). Motivation is generally defined as a psychological process that notifies purpose, direction and intensity to people's behavior (Mwangi & McCaslin, 1994). According to researchers (Brophy, 1983; Good & Brophy, 1997), students' motivation to succeed in mathematics is a cognitive response including attempts to make sense of an activity of mathematics, understand its relation to prior knowledge, and master the skills it promotes.

Studies made the significance of motivation clear for student learning and achievement (Elliot & Dweck, 2005) also in the domain of mathematics (Graham & Weiner, 1996; Gottfried, Fleming, & Gottfried, 2001). Researchers have found out that motivation tends to be domain-specific (Marsh & Yeung, 1997) which is a better predictor of student achievement than more general motivation (Graham & Weiner, 1996; Schiefele & Csikszentmihalyi, 1995). Domain-specific motivation was also found to affect students' choices of courses in high school, college majors, and career paths and has enduring effects throughout students' lifes (Anderman& Maehr, 1994; Gottfried, et al., 2001).

Additionally researchers determined that motivation has three subdimensions; intrinsic motivation, extrinsic motivation and achievement motivation. Researchers agree that intrinsic motivation is about students' interest in a topic or activity and defined as students' engagement in an activity for its own sake (Pintrich & Schunk, 1996). This kind of motivation is based on the assumption that humans are naturally motivated to develop their intellectual and diverse competencies and they enjoy their accomplishments (Stipek, 1998). Extrinsic motivation refers to doing something because it leads to a separable outcome and the value an individual places on the ends of an action and the possibility of reaching these ends (Ryan & Deci, 1999). Achievement motivation is more relevant to performance on tasks. It is well documented in the literature that students' intrinsic, extrinsic, and achievement motivation is an important factor for their mathematics achievement (e.g., Ames, 1992; Middleton, 1993; Wolters, Yu, & Pintrich, 1996). Accordingly the motivation scale developed by Ramsden and Entwistle (1981) will be used for this study which includes the mentioned three subdimensions.

2.7.2 Self-efficacy

Self-efficacy is described as people's judgement of their own abilities to successfully establish and execute courses of action to meet desired outcomes (Bandura, 1986). Hence self-efficacy has a considerable effect on individuals' choices and actions. Effects of self-efficacy on academic performance and motivation has been demonstrated by a large body of empirical findings (e.g. Bandura, 1986, 1997; Pajares & Kranzler, 1995; Schunk, 1991). The critical place of mathematics in the school curriculum, its centrality in high-stakes testing and its importance in career choices yielded research on self-efficacy to give notice to the subject (Pajares & Graham, 1999). It has been shown by the research that regardless of the intellectual ability level self-efficacy contributes to academic performance and correlates strongly with academic outcomes, attitudes towards mathematics and math axiety in school mathematics (e.g., Pajares, 1996; Pajares & Graham, 1999). Moreover, self-efficacy as a better predictor than acquired skills and its governing influence on other constructs' such as past performance and skills was also identified (Pajares & Graham, 1999).

Primary studies examined confidence in learning mathematics, which is counted as a conceptual analogous of mathematics self-efficacy, has consistently been found to predict mathematics behaviour and performance (Reyes, 1984). Various research studies have reported the students' judgments of their own capabilities in mathematics is predictor of their actual capabilities. Mathematics self-efficacy has been shown to be a strong predictor of mathematical problem-solving capability as general mental ability (Pajares & Kranzler, 1995). Other studies have reported that when students with high self-efficacy approach academic tasks, work harder and for longer periods than students with lower self-efficacy (Collins, 1982; Schunk, 1989, 1991).

Strong correspondence between self-efficacy and academic performance has been determined through the literature (Colllins, 1982; Pietsch, Walker, & Chapman, 2003). Colllins (1982) found that students with high self-efficacy outperformed students with low self-efficacy in mathematical problems, also they showed more effort and persisted longer for reworking incorrect problems, when prior performance was controlled. The fact that self-efficacy functions as a predictor of academic achievement is specified in the literature. Statistically significant and positive relations were found between self-efficacy beliefs and academic performance (Moulton, Brown, & Lent, 1991). The fact that mathematics self-efficacy being more predictive of problem solving than mathematics self-concept, gender and prior mathematics experience was found by Pajares and Miller (1995). It was also found that undergraduate students' mathematics self-efficacy was highly predictive of their choice of major when controlling mathematics aptitude and anxiety (Hackett & Betz, 1989).

Mathematics self-efficacy has been assessed typically with asking individuals to specify their strength in mathematical tasks on Likert-type scales (Pajares & Miller, 1997). Students judge how confident they are in particular situations or problems. Self-efficacy is a context specific assessment of competence in carrying out a specific task (Pajares & Miller, 1994). It is argued that this difference is what makes self-efficacy measures consistently more predictive than general constructs (Bandura, 1997). Judgements of self-efficacy are mentioned to be context specific, even item or task specific (Pajares & Miller, 1994). What is problematic in general is that students are asked to generate judgments about their capabilities in an academic domain in mind, instead of the specific tasks (Pajares, 1996).

Apart from the specificity in the assessment of self-efficacy, researchers suggest for the items to correspond directly to the criterion of performance (Bandura, 1986). The task specific judgements of self-efficacy assessment was examined by Pajares and Miller (1995) and they suggest that global and generalized self-efficacy assessments might predict performances that are not specifically related. Moreover students' task-specific self-efficacy was found to be the only affective variable to predict performance (Pajares & Graham, 1999). Besides the meta-analytic study by Moulton, Brown, and Lent (1991) confirmed the usefulness of these criteria and their necessity for consistent and valid research on self-efficacy. In this study, these criteria were considered and applied to the self-efficacy items. Hence the self-efficacy scale for derivative is developed by the researcher because of the deficiency of such a scale.

2.7.3 Anxiety

Anxiety is generally defined to be a state of emotion underpinned by qualities of fear and dread (Lewis, 1970). Some researchers define mathematics anxiety as same with the subject-specific test anxiety (Brush, 1981). Others describe its context largely, including a general fear of mathematics or fear of tests in particular (Richardson & Woolfolk, 1980). In 1972, Richardson and Suinn described mathematics anxiety as involving anxiety and tension feelings which interfere with the use of numbers and mathematical problem solving situations in academic and real life situations.

The first systematic instrument to assess mathematics anxiety was the Mathematics Anxiety Rating Scale (MARS), published by Richardson and Suinn (1972). Many mathematics anxiety scales developed afterwards are versions of MARS (e.g. Plake & Parker, 1982; Suinn, 1988; Alexander & Martray, 1989). This scale was frequently used by many studies, hence the validity and reliability of the MARS have been widely studied (e.g., Dew et al. 1984; Resnick, Viehe, & Segal, 1982; Resnick et al., 1982; Richardson & Suinn 1972; Strawderman, 1985; Suinn & Edwards 1982). However, the scale has two shortcomings that it is time consuming and unidimensional (Alexander & Martray, 1989). Hence to overcome these shortcomings, Suinn and Winston (2003) developed a short version of the scale (MARS-SV). This scale was adapted to Turkish population by Baloğlu (2010) and was found to be reliable and valid. Moreover, studies using this scale showed evidence of its reliability and validity (e.g., Pamuk & Karakaş, 2011).

A significant moderate and negative correlation between mathematics anxiety and achievement has been reported by some researchers (Adams & Holcomb, 1986; Betz, 1978; Brush, 1978; Cooper & Robinson, 1991; Cowen, Zax, Klein, Izzo, & Trost, 1963; Dew et al., 1984; Lunneborg, 1964; Resnick et al., 1982; Suinn, Edie, Nicoletti, & Spinelli, 1972; Wigfield & Meece, 1988). There is a rather extensive literature on personal and educational consequences of mathematics anxiety (see Hembree, 1990). Briefly the research studies showed that beyond a certain degree, anxiety acts as an obstacle for the performance especially in the case of higher mental activities and conceptual process (Skemp, 1986). Students with higher anxiety levels tend to avoid mathematics whenever or wherever possible (Daane & Tina, 1986). The correlation between mathematics anxiety and academic performance is found to be negatively significant (Ashcraft & Kirk, 2001). Moreover students with high levels of mathematics anxiety have lower levels of mathematics achievement (Clute, 1984; Hembree, 1990). It was also noted that in mathematical tasks, mathematics anxiety constrains performance seriously. Additionally, decrease in anxiety is related to the improvement in achievement consistently. Students with high level of mathematics anxiety lack confidence in their mathematical abilities and are inclined to take least numbers of required mathematics courses (Garry, 2005). Mathematics anxiety also causes challenges for processing not only the recent information but also the previously learned information for problem solving (Daane & Tina, 1986). Because of being appropriate and feasible for the current study, MARS-SV will be used.

2.7.4 Socioeconomic Status

Socioeconomic status (SES) describes an individual's ranking on a hierarchy according to access some combination of valued commodities such as wealth and social status (Mueller & Parcel, 1981). There is an agreement that SES is composed of three main indicators; parents' education, parents' occupation, and family income (e.g., Bradley & Corwyn, 2002; Duncan, Featherman, & Duncan, 1972; Gottfried, 1985; Hauser, 1994). Socioeconomis status (SES) has been a widely accepted variable in educational research from the findings of Coleman et. al (1966) which began the discussion of the effects of SES on academic achievement. Research studies found SES as a strong predictor of school achievement (Byrnes & Wasik, 2009; Caldas, 1993; Caldas & Bankston, 2001; Coleman et al 1966; Entwistle & Alexander, 1992; Sirin, 2005; White, 1982).

Moreover, it has been shown that middle and upper socioeconomic status students enter schools with higher achievement levels in mathematics than lover socioeconomic status students. Across various assessments, a strong relationship between socioeconomic status and mathematics achievement was evident (Green et al, 1995). These results demonstrate the need to take SES into account when studying students' learnings, even in high education. Hence SES is an important factor to consider in studies of student learning. In this study, the SES will be measured via items of parents' education, parents' occupation, and family income.

2.8 Modeling Studies in Mathematics Achievement

Studies investigated university students' affective traits with structural modeling. The findings show that self-efficacy performs as the mediator of affective characteristics, learning approaches and mathematics achievement. The affective factors (teaching attitudes towards mathematics, mathematics self-concept, mathematics teaching self-efficacy, mathematics beliefs) and their influences on mathematics achievement were investigated with structural modeling in the study by Leung and Man (2005). Mathematics self-efficacy directly influences achievement (Leung & Man, 2005).

Additionally, there are also efforts to develop structural models which clarify the mathematics achievement of students with student related factors such as some affective factors (Mousoulides & Philippou, 2005). In this respect, motivational beliefs such as self-efficacy, and mathematics achievement were examined among university teachers. It was found that self-efficacy has a strong positive effect on mathematics achievement. Moreover, there exist studies investigating factors (e.g., attitude towards mathematics, achievement motivation, self-efficacy) influencing mathematical problem-solving ability of elementary students (Pimta, Tayruakham, & Nuangchalerm, 2009). It was found out that self-efficacy has positive indirect effect on the mathematical problem solving of students by through achievement motivation, attitude and concentration. However, there is no specific study in the literature addressing the derivative achievement in line with its prerequisite concepts.

2.9 Model Specification

The mentioned findings of the research studies lead the model development presented in Figure 1.1. Examining the studies in the literature in line with MNT, it can be seen that the retrieval cognitive domain of prerequisite knowledge includes mainly executing the prerequisite knowledge. In this level students are not expected to demonstrate the knowledge in depth. According to the present study, retrieval cognitive domain of prerequisite knowledge includes retrieving, recalling, or executing the prerequisite knowledge. More specifically, in this cognitive level students are exected to determine the degree of a polynomial, determine the intersection points of a graph to the xy-axes, make simple simplification operations and demonstrating secong degree equations.

In the present study, the comprehension cognitive level of prerequisite knowledge includes the use of symbols of functions and algebraic expressions. Besides, a student in the analysis cognitive level of prerequisite knowledge, examines the knowledge in the prerequisite concepts with the intent of generating new conclusions. Analysis cognitive skill of prerequisite knowledge includes the cognitive skills of discriminating the piecewise functions, identifying dependent and independent variables in problems, diagnosing and editing indeterminate limits, and making conclusions of the rate of change from the graph of a function. Moreover, the knowledge utilization in the prerequisite knowledge of derivative is about applying or using knowledge in specific situations for four of the prerequisite concepts of derivative. This cognitive level includes making decisions for the limit of the secant lines and solving problems of limit of a series and functions with restricted conditions.

In this study, the retrieval cognitive level of derivative includes applications of simple derivative taking rules and recalling the fact that the derivative of the minima and maxima of a function is zero. Additionally, comprehension cognitive domain of the derivative includes integrating and symbolizing the derivative. That is; identifying critical or essential elements of the differentiable functions and depicting the critical aspects of the derivative symbols and different forms of the limit definition of derivative.

The analysis cognitive domain of derivative includes forming conclusions of real life applications for derivative such as interpreting graphs and instantaneous rate of change. Besides, making inferences for the function from the graph of a derivative function is also included in the analysis cognitive domain of derivative. Utilization of the knowledge of derivative is the desired goal for students' derivative achievement. The knowledge utilization of derivative includes developing a strategy to solve minimum/maximum problems, drawing the graph of a function with derivative knowledge and generating the tangent line from the secant lines.

As seen in Figure 1.1, the student related factors are expected to have relationships directly with the prerequisite knowledge and also directly or indirectly with the derivative knowledge. One of the reasons of this fact is that students are affected from the student related factors the most when they are in the secondary school, namely when they are taught the prerequisite knowledge of derivative. Another reason can be stated as the fact that more studies in the literature show the impact of student related factors on the prerequisite knowledge, while their effects on the derivative is not specifically studied in detail (Alexei & Richard, 2010; Middleton & Spanias, 1999).

Moreover, motivation being an important affective factor for achievement is studied widely for the literature for prerequisite knowledge of the derivative. However the more students develop in cognitive skills, the more successful and motivated they are (Elton, 1988; Ryan & Pintrich, 1997).

CHAPTER 3

METHODOLOGY

This chapter involves the methodology of the study comprising population and sample, the development of the instruments together with their validity and reliability, procedural details, data collection and data analysis including the structural equation modeling.

3.1 Research Design and Procedure

The data for the current study were collected through the survey. The survey includes Demographic Profile Questionnaire (DPQ), Affective Characteristics Questionnaire (ACQ) and Derivative Achievement Test (DAT). All of the instruments were administered within a single survey booklet by the help of the instructors. The intact groups were used in the study. The students were informed by the instructors in advance about the administration and the consent forms were obtained from the students. The survey was administered in one course hour which is approximately 40 to 50 minutes.

3.2 Sample

The target population of the study is the university students who take undergraduate calculus courses. Hence, the population of interest is restricted to the university students who had taken or are taking the calculus courses during the data collection process.

In Turkey, students encounter the derivative concept for the first time in 11th and 12th grade levels at high school (Board of Educational Discipline, 2013). Students who continue their university education in the faculties of science, engineering, and education are obliged to take calculus courses and are taught the derivative concept throughly. Moreover, in these departments, derivative constitutes a major role in most courses and many phases along the university education. In the current study the convenience sampling was used.

The subjects of the study were the students who were enrolled to the universities in 2012 spring semester from seven provinces, in the cities of Aksaray, Ankara, Bolu, Karaman, Kayseri, Tokat, and Zonguldak. The sample includes 1660 undergraduate students in the these cities. The demographic profiles and major characteristics of the students are shown in Table 3.1.

Table 3.1: Major Characteristics of Participants

Gender	**Frequency**	**Percentage (%)**
Female	929	55.96
Male	731	44.04

Table 3.1 (Continued)

Total	1660	100.0
University	**Frequency**	**Percentage (%)**
Middle East Technical University	261	15.72
Ankara University	107	6.45
Hacettepe University	363	21.87
Gazi University	269	16.20
Bilkent University	47	2.83
Baskent University	37	2.23
Aksaray University	179	10.78
Gaziosmanpaşa University	85	5.13
Bülent Ecevit University (Zonguldak)	56	3.37
Erciyes University	59	3.55
Karamanoğlu Mehmetbey University	73	4.40
Abant Izzet Baysal University	124	7.47
Total	1660	100
Department	**Frequency**	**Percentage (%)**
Mathematics	232	13.98
Physics	30	1.81
Chemistry	59	3.55
Biology	27	1.63
Statistics	80	4.82
Computer Engineering	15	0.90
Environmental Engineering	17	1.02
Electric and Electronic Engineering	134	8.08
Industrial Engineering	103	6.20
Food Engineering	21	1.26
Civil Engineering	33	1.99
Geology Engineering	22	1.32
Mining Engineering	33	1.99
Mechanical Engineering	70	4.22
Nuclear Energy Engineering	45	2.72
Aerospace Engineering	63	3.79
Elementary Mathematics Education	290	17.47
Elementary Science Education	211	12.71
Computer Education and Instructional Technology	139	8.37
Secondary Mathematics Education	36	2.17
Total	1660	100
Year	**Frequency**	**Percentage (%)**
1	541	32.59
2	437	26.33

Table 3.1 (Continued)

3	527	31.74
4	155	9.34
Total	1660	100
CGPA (out of 4.00)	**Frequency**	**Percentage (%)**
0.12 – 1.38	96	5.78
1.39 – 2.02	287	17.29
2.03 – 2.69	589	35.49
2.70 – 3.34	492	29.63
3.35 – 4.00	196	11.81
Total	1660	100
Age (Year)	**Frequency**	**Percentage (%)**
Between 18 and 20	595	35,84
Between 21 and 23	869	52,35
Between 24 and 26	158	9,52
27 and older	38	2,29
Total	1660	100

According to the Table 3.1, most of the data were collected from the city of Ankara which is located in the Central Anatolia Region. This is the result of the fact that Central Anatolia Region, mainly Ankara is one of the cities in which most of the universities in Turkey are located (Higher Education Council, 2013).

3.3 Instrumentation

Three instruments were administered in the data collection. These are Demographic Profile Questionnaire (DPQ), Affective Characteristics Questionnaire (ACQ) and Derivative Achievement Test (DAT). These three instruments were included in one booklet which is called as the survey. Below, each of the instruments used in the study are explained individually.

3.3.1 Demographic Profiles Questionnaire

The Demographic Profiles Questionnaire (DPQ) was developed by the researcher. The DPQ includes items about: participants' gender, age, university, department, grade level, Cumulative Grade Point Average (CGPA), and items of students' socioeconomic status (SES). SES items include number of books at home, internet facility at home, computer for the common use at home, personal computer, family's income, mother's and father's education levels. The items of the demographic profiles of the students in the test ranged from item 1 to item 12 in the survey booklet (See Appendix A).

Three experts were asked about the appropriateness, meaningfulness and understandability of the items in the DPQ (see Appendix B for the checklist for validity). All of the items in DPQ were agreed to be appropriate, meaningful and understandable for the sample of the study. This was done for the purpose of face validity.

The DPQ was administered to the second year university students who were studying in Aksaray University in the elementary mathematics education for the purpose of piloting. The group consisted of 56 students. The reliability coefficient as estimated by Cronbach's alpha was found to be 0.865 for this data. Therefore the DPQ is proved to be convenient to use for the current study.

3.3.2 Affective Characteristics Questionnaire

The Affective Characteristics Questionnaire (ACQ) consisted of three sub-scales. These scales were the Mathematics Motivation Scale (MMS), Mathematics Anxiety Rating Scale-Short Version (MARS-SV), and Derivative Self-efficacy Scale (DSS).

3.3.2.1 Mathematics Motivation Scale

Motivation is an important construct which has a significant role in achievement. However studies examining mathematics motivation concentrated mostly on the younger students in primary or secondary education levels. Few scales were developed for measuring the mathematics motivation of university students (e.g., Amit, 1988). In the present study the researcher decided to use one of the subscales of Approaches to Studying Inventory (ASI) (Ramsden & Entwistle, 1981) since it was already adapted for the Turkish university students, and moreover, it is short enough to collect data among the other measuring instruments used in the present study (Hei, 1999).

The Mathematics Motivation Scale (MMS) is generated with the dimensions related to students' motivation in ASI, namely the dimensions of intrinsic motivation, extrinsic motivation, and achievement motivation. MMS is a Likert type instrument with 5-point response categories ranging from *strongly disagree* (1) to *strongly agree* (5). The items related to intrinsic motivation (item 13 through item 16), extrinsic motivation (item 17 through item 20), and achievement motivation (item 21 through item 23) of MMS are presented in Appendix A.

The ASI and thereby the motivation sub-scales of ASI were validated by the test developers (Ramsden & Entwistle, 1981). The validation was conducted on 2208 students from 66 academic departments in six disciplines. The factor analyses of this instrument was confirmed with the factor structures of the the sub-scales of intrinsic, extrinsic and achievement motivation. Moreover the ASI was adapted into Turkish language by Hei (1999). The scale was validated with Turkish university students and the intrinsic, extrinsic and achievement motivation again emerged as the motivation sub-scales of ASI (Berberoglu & Hei, 2003; Hei, 1999). The reliability coefficient as estimated by Cronbach's alpha was found as 0.73 for the data obtained from Turkish students (Berberoglu & Hei, 2003). These values make the motivation sub-scales of ASI useful for the present study while the Cronbach's alpha value for the motivation sub-scale of ASI obtained with the main data of the study is 0.79.

3.3.2.2 Mathematics Anxiety Rating Scale-Short Version

Mathematics anxiety is an important feature affecting students' achievement (Alexander & Martray, 1989; Ashcraft & Kirk, 2001; Garry, 2005; Hackett & Betz, 1989). This is also consistent for mathematics, specifically in higher education. Hence in this study, for the aim of controlling this extraneous variable, students' mathematics anxiety is measured. The scale administered in this study is Mathematics Anxiety Rating Scale-Short Version (MARS-SV) which was originally developed by Suinn & Winston (2003). Mathematics Anxiety Rating Scale (MARS) is the first and the basic systematic instrument to assess mathematics anxiety. This scale was frequently used by many studies and has strong validity evidence and high reliability coefficient (e.g., Camp, 1992; Dew et al. 1984; Resnick et al., 1982; Richardson and Suinn 1972; Suinn and Edwards 1982). MARS-SV is the short version of MARS which overcame some of the shortcomings like being time consuming (Suinn and Winston, 2003). The scale, MARS-SV was adapted to Turkish by Baloğlu (2010). The Turkish scale was administerd to 475 university level students. Hence Turkish version of MARS-SV was found to be the most appropriate scale to assess students' mathematics anxiety in the study.

This scale includes 30 items in the Likert-type format with the five alternatives ranging from *not anxious at all* (1) to *extremely anxious* (5). The scale has five dimensions as; the mathematics test anxiety, course anxiety, application anxiety, computation anxiety, and social anxiety. The items of the anxiety scale of the current study are presented in Appendix A from item 24 to item 53.

MARS-SV has the reliability coefficient 0.96, as estimated by Cronbach's alpha (Suinn & Winston, 2003). The Turkish version of MARS-SV was validated by twenty-five bilingual experts agreeing on the language equivalency, and 49 Turkish language experts agreeing on the conformity and understandability of the scale's items. Besides thirty-two subject matter experts' responses provided evidence for content validity (Baloğlu, 2010). The reliability coefficient of the Turkish version of MARS-SV was 0.93 as estimated by Cronbach's alpha (Baloğlu, 2010). The reliability coefficient of the scale estimated by Cronbach's alpha for the data of the current study is 0.84.

3.3.2.3 Derivative Self-efficacy Scale

The Derivative Self-efficacy Scale (DSS) was developed by the researcher with the aim of measuring university students' self-efficacy beliefs towards derivative. In the literature, self efficacy is generally taken as a contextual fashion where efficacy of the respondents are assessed by the use of questions reflecting the details of subject matter. Thus, the context of task specificity of DSS requires the items to be directly related to the objectives of the subject-matter. A self-efficacy statement is exact like: "Can you solve this specific problem?" (Pajares & Miller, 1994). The researcher developed the items for this questionnaire by writing statements like "Can you graph functions with the help of derivatives?" or "Can you take derivative of some functions?".

Being in line with the suggestions of the literature, the DSS has 8 items of the general objectives of the derivative concept. DSS was a Likert-type scale, including 5-point response categories ranging from from *not competent at all* (1) to *extremely competent* (5). The items of the DSS are given in Appendix A, from item 54 to item 61.

For the purpose of collecting evidence for validity, expert opinions were gathered for the items of the DSS. The experts were two mathematics educators, one professor with mathematics major, and two Turkish language experts. The experts were informed about the self-efficacy scales and were asked about the appropriateness, meaningfulness and understandability of the items in the DSS. All items in DSS were agreed to be appropriate, meaningful and understandable for the sample of the study. This was done for the purpose of face validity.

The DSS was administered to the second year elementary mathematics education students in Aksaray University for the purpose of piloting. The Cronbach's alpha reliability of the DSS for the total of 56 students was 0.85. Hence these parameters show that the scale operates as required to be used in the present study. Besides the reliability coefficient of the scale estimated by Cronbach's alpha for the data of the current study is 0.89.

3.3.3 Derivative Achievement Test

The Derivative Achievement Test (DAT) was developed by the researcher with the aim of measuring university students' achievements of both the derivative and its prerequisite knowledge. Some studies assessed students' derivative achievement (e.g. Orton, 1983; Viholainen, 2008). However these studies did not cover the subject with the consideration of the prerequisite knowledge and the cognitive skills. Consequently the DAT, including two tests of questions of derivative and its prerequisite knowledge was developed by the researcher.

The DAT includes 29 questions in total with open-ended and restricted-response formats. In the DAT, there are 6 open ended questions requiring short answers. The restricted-response questions were consisted of 17 multiple choice and 6 true-false questions. The DAT includes the prerequisite test with 17 questions and the derivative test with 12 questions measuring the derivative knowledge.

Prior to the development of DAT, a test plan was prepared for derivative and prerequisite concepts (see Appendix C). The cognitive dimension of the test plan includes the four cognitive levels of MNT named and summarized as retrieval, comprehension, analysis, and knowledge utilization. Moreover, as it is seen from the test plan, the subject matter domain for the derivative includes the following sub-topics: derivative taking rules, symbols used in derivatives, limit definition of derivative, secant and tangent lines, graphical interpretations of derivative, instantaneous rate of change, and minimum/maximum problems.

At first 36 questions in various formats was designed with respect to the test plan. There were 18 questions of the prerequisite concepts and 18 questions of the derivative concept. The questions were prepared to measure both the corresponding subject matter dimension and the cognitive processes. While some questions were prepared by the researcher, some were adapted from other tests used in the same field (e.g.; Orton, 1983; White & Mitchelmore, 1996).

For the purpose of obtaining content related validity evidence, two research assistants and one instructor in the department of Mathematics Education and additionally one instructor in the department of Mathematics classified the questions. The experts examined the questions across the cognitive levels and the subject matter dimensions used in the table of specifications in a checklist. The checklist is presented in Appendix D. Additionally the experts were asked in the same checklist; whether the questions were appropriate as content for the undergraduate students, whether content is represented appropriately, whether the format is appropriate, and the language is understandable. The checklists filled out by the experts were analyzed. The congruence between the plan of the study and the experts' classifications was calculated. The congruence of the checklist was 70% at least and 97 % at most. After this step, in the light of expert opinions about the test, some questions were corrected in format, language, or mathematics. On the other hand, the disagreements on some questions were discussed with each expert and a consensus was obtained. There were three questions in the test which were inappropriate because of the cognitive or subject matter dimensions. These questions were excluded from the DAT. Consequently in the end of this step, the DAT included 33 questions.

The final version of the DAT was administered to a group of students in Aksaray University in 2010 spring semester for the purpose of piloting. The administration was conducted with a total of 56 students who were preservice mathematics teachers in the second year of their study. The purpose of this administration was to conduct psychometric analyses in the question and test score levels. Moreover this administration was conducted to check if the time given to the students for the test is sufficient. The students were given one course hour to complete the test. During this administration, the instructor of the course was present. Students' questions about the test were considered for further evaluating questions in terms of content, clarity and language. The piloted test included 33 questions. The true answers of the questions were scored as 1 and false answers of the qestions were scored as 0. The reliability of the scores from the data obtained from the 56 students was estimated with Cronbach's alpha as 0.788.

The item analyses of the DAT after the administration to 56 students are presented in the current paragraph. Item difficulty is defined as the proportion of test takers who answered the question correctly. Item difficulty is also called as called difficulty index or p-value, where p is the number of students who answered the question correctly divided by the total number of students who answered the question. For classroom achievement tests, most test constructors try to find items with indices of difficulty in between 20 and 80, with an average index of difficulty from 30 or 40 to a maximum of 60 (Lord, 1980; Hambleton, Swaminathan, & Rogers, 1991).

In questions 7, 11 and 24 the proportion endorsing for the correct response are 0.196, 0.157, and 0.104 respectively. The p-values of questions 7, 11 and 24 are too low. The content of the correct option should be reviewed to insure its accuracy. The first distractor of question 7 has positive biserial value 0.318. This information means that this option is not functioning well and it has been selected by high-scoring examinees. The first option of question 7 is altered to make it less attractive. On the other hand the question 28 is in open-ended format. For the question 28, 1 represents incorrect responses; 2 represents partial correct responses and 3 represents correct responses. High proportion of examinees has answered the question incorrectly. The proportion endorsing of 1 is 0.857 and it can be also said only 10.4% of examinees have given correct response.

Item discrimination can be described as the correlation between the item score and test score. By using biserial correlation coefficient, item discrimination can be investigated. If biserial correlation value for the correct response is greater than 0.40, the item is functioning quite satisfactorily (Backhoff, Larrazolo, Rosas, 2000). If biserial correlation value is between the values of 0.30 and 0.40, little or no revision is required. If biserial correlation value is between the values of 0.20 and 0.30, the item needs revision. If it is below 0.19, the item should be eliminated or totally revised (Ebel's criteria, Ebel & Frisbie, 1986). In the test there was no question with biserial value below 0.40. After conducting the mentioned item analysis, the four questions numbered as 7, 11, 24 and 28 were removed from the final version of the test and the DAT included 29 questions in its final version. The scoring of the DAT was conducted as 1 for the rigt answers and 0 for the wrong answers. The final version of DAT has the Cronbach's alpha value 0.797, as obtained from the data of the 56 university students. The final version of the DAT is presented in Appendix E and the answer key for DAT is presented in Appendix F respectively.

3.4 Data Processing and Analysis

After the data were collected various exploratory factor analyses were conducted for the aim of identifing the dimensions of the tests. Depending on the related literature and the results of the analyses, factors were determined for further analysis. Accordingly, observed variables with high factor loadings were selected as the latent variables. Subsequently, separate confirmatory factor analyses were conducted for each of the instrument. The model given in Figure 1.1 was constituted and tested.

The DAT included questions of both the prerequisite and the derivative concept. After gathering the data, the DAT was divided into two tests including the prerequisite questions and the derivative questions. These tests were named as the prerequisite test and the derivative test. Additionally, the variables of ACQ are considered with SES in the results and referred to as affective variables. The data gathered from DPQ, ACQ and DAT were analyzed by SPSS 17.0 program and LISREL 8.71. The data were analyzed within various exploratory factor analyses in order to identify the factor structure of the DPQ, ACQ and DAT. After determining the factors, necessary changes were made by removing the problematic items (e.g., items 7, 11, 24, and 28 before the pilot testing) from further analyses. Separate Confirmatory Factor Analyses (CFA) were carried out for validating non-directly observable factors that were determined as result of exploratory factor analyses. To improve the fit of the models, the suggested modifications were conducted. Then, the Structural Equation Modeling (SEM) techniques were employed to test the overall model fit and the significance of the relationships among the latent variables. Maximum likelihood method was used to estimate the model parameters. In particular to evaluate the extent to which the data fit the models tested, scaled chi-square, Comparative Fit Index (CFI), and the Root Mean Square Error of Approximation (RMSEA) were examined.

3.4.1 Treatment of Missing Data

The statistical analyses might be impacted by the missing items. Hence, to identify the percentage of missing values for every item and case, missing value analysis was carried out. In case of any item in one of the questionnaires or the DAT being left unanswered, it was coded as NA which denotes “no answer”. The students who did not complete one of the scales completely (DPQ, ACQ, or DAT) were excluded from the sample. Almost 5 % of the students were deleted from the analysis.

The acceptable range of the missing data in a variable level should be less than or equal to 10% (Pallant, 2007). The highest missing range was found to be around 8.85 % in the present study. Therefore, missing entries of the Likert type items in DPQ or ACQ were replaced by the mean of that specific variable. The missing values for the DAT were substituted by zero indicating wrong answer which is a common replacement practice for achievement tests (McKnight, McKnight, Sidani, & Figueredo, 2007).

3.4.2 Effect Sizes

A measure of the effect size indicates the degree of the relationship among variables. In other words, it is an indicator of the relationship between two or more variables (Stevens, 2002). For correlational studies, the squared multiple correlation coefficients (R^2) are used to indicate the effect sizes. The classification for effect sizes which were measured in terms of R^2. *As* suggested, $R^2 = 0.01$ is small, $R^2 = 0.09$ is medium, and $R^2 = 0.25$ is large effect size (Cohen, 1988). The classification for standardized path coefficients (R) for interpreting the effect sizes of the relationships where absolute values of the path coefficients that are less than 0.10 are considered small, 0.30 as medium and greater than 0.50 as large effect sizes. (Cohen, 1988).

3.4.3 Structural Equation Modeling

The Structural Equation Modeling (SEM) was used as a statistical technique in the current study. The aim of using SEM is to test and estimate the casual relations stated in Figure 1.1. It is possible to conduct both confirmatory and exploratory modeling with SEM, namely SEM is suited to both theory testing and theory development. In the current study the confirmatory modeling is conducted with SEM. Confirmatory modeling starts with a hypothesis which is denoted in a causal model. The hypothesized model in the current study is given in Figure 1.1. Then, the concepts used in the model are operationalized to allow testing of the relationships between the concepts in the model. The model is tested on the obtained data to determine how well the model fits the data.

One of the strengths of SEM is the construction of the latent variables. These variables are not measured directly, but are estimated in the model from several measured variables each of which is predicted to connect the latent variables. This allows to clearly capture the unreliability of measurement in the model, which in theory allows the structural relations between latent variables to be accurately estimated.

The vital starting point of the modeling procedure is the model specification. The model of the present study is employed on the basis of the detailed literature review. The hypothesized model clarifies both which relationships are expected to see in the data and which of them are not expected to emerge (Kelloway, 1998).

3.4.3.1 Definition of Terms for Structural Equation Modeling

1. Path Diagram

Path diagram is the pictorial or symbolic representation of a structural equation model which indicates the relations. A path diagram in which variables are linked by bidirectional curved arrows or unidirectional arrows show the structural relations which together form the model. The unidirectional arrows denote causal relations and besides bidirectional curved arrows denote noncausal or correlational relationships (Kelloway, 1998). In other words, the path diagram contains the indication of all parameters in one model (Hoyle, 1995).

2. Observed or Manifest Variables

Observed variables are also named as indicators and they are both directly observable and measurable variables like test items or questionnaire items (Schumacker & Lomax, 2004).

3. Latent or Unobserved Variables

These variables are the ones that are not measured directly (Kelloway, 1998). However, they can be indirectly measured by the observed variables (Schumacker & Lomax, 2004).

4. Latent Dependent Variables

Latent dependent variables are influenced by other latent variables in the model. The measurement of these variables depends on the observed dependent variables.

5. Latent Independent Variables

Latent independent variables are not influenced by any other latent variable in the model. The measurements of these variables depend on the observed independent variables.

6. Structural Equation Models

The factors are established as latent variables in the path models by which the structural equation models are represented. Structural equation models show the relationship between latent variables and observed variables in a theoretical perspective. There are two parts in a structural model which are (i) the measurement model and (ii) the structural model.

7. The Measurement Model

It is the component of the general model in which latent variables are prescribed (Hoyle, 1995). The purpose of a measurement model is to explain how well the observed indicators function as a measurement instrument for the latent variables (Jöreskog & Sörbom, 1993). This explanation is made on the basis of the confirmatory factor analyses in terms of the factor loadings. The measurement properties of the latent variables such as validity and reliability are specified in this model.

8. The Structural Model

It is the part of the general model that prescribes relations between latent variables and observed variables that are not indicators of latent variables (Hoyle, 1995). This model gives the direct and indirect relationships among latent variables that clarify the amount of explained and unexplained variance. In this sense, the structural model is an indication of the extent to which hypothesized relationship is supported by the data (Schumacker & Lomax, 2004).

9. Direct Effect

The direct effect indicates a directional relation between two variables, that is the characterization of the relation among an independent and a dependent variable. The path coefficients, that represent the direct effects in the model, are the building blocks of the structural equation models.

10. Indirect Effect

The indirect effect indicates the effect of an independent variable on a dependent variable through one or more mediating variable (Hoyle, 1995).

11. Total Effect

The total effect indicates the sum of direct and indirect effects of an independent variable on a dependent variable.

12. LISREL 8.71 with SIMPLIS Command Language

LISREL is a computer program (Jöreskog & Sörbom, 1993) that uses the SIMPLIS command language in order to perform structural equation modeling. A more national language is used in SIMPLIS language to define LISREL models (Kelloway, 1998) in which path models are generated concerning a model formulation.

13. The Measurement Coefficients

The λ_y (lowercase lambda sub y) and λ_x (lowercase lambda sub x) values designates the relationships between the latent variables and observed variables. These values can also be defined as factor loadings, which specify the validity coefficients.

The Ɛ (lowercase epsilon) and δ (lowercase delta) show the measurement errors for the Ys and Xs, respectively. These values function as reliability coefficients.

14. The Structure Coefficients

The β (lowercase beta) values describe the strength and direction of the relationship among the latent dependent variables.

The γ (lowercase gamma) values indicate the strength and direction of the relationship between latent dependent variables and latent independent variables.

15. Factor Analysis

Factor analyses are integrated in structural equation modeling for creating the latent variables by reducing a large number of variables to a small number of factors. For modeling purposes two types of factor analysis can be used.

15.1 Exploratory Factor Analysis (EFA)

This technique is used to establish the factors, which are independent among each other. In Exploratory Factor Analysis (EFA), the number of factors is explored along with whether the factors are correlated, and which observed variables appear to best measure for each factor (Schumacker & Lomax, 2004).

15.2 Confirmatory Factor Analysis (CFA)

This technique is used to determine if the number of factors and the loadings of the observed variables on them confirm to what is hypothesized, regarding a theory. In CFA, a some number of factors is specified, along with which factors are correlated, and which observed variables measure each factor (Schumacker & Lomax, 2004).

3.4.3.2 The Goodness-of-Fit Criteria for Structural Equation Modeling

In this study LISREL 8.71 for Windows with SIMPLIS Command Language was used in formulating and estimating the models including factors affecting derivative knowledge of university students. These criteria are used to determine to which degree the structural equation model fits the sample data.

The goodness-of-fit indexes used in the study are; Chi-square (χ^2), Goodness-of-Fit Index (GFI), Adjusted Goodness-of-Fit Index (AGFI), Root-Mean-Square Residual (RMR), Standardized-Root-Mean-Square Residual (S-RMR), Root-Mean-Squared Error of Approximation (RMSEA), Normed Fit Index (NFI), Non-normed Fit Index (NNFI), Comparative Fit Index (CFI), Incremental Fit Index (IFI), Relative Fit Index (RFI), Relative Normed Fit Index (RNFI), Cross-Validation Index, Expected Value of Cross-Validation Index (ECVI), Normed Chi-Square (NC), Parsimonious Fit Index (PFI), Parsimonious Normed Fit Index (PNFI), and Parsimonious Goodness-of-Fit Index (PGFI). The criteria for these indexes are as given in Table 3.2 (Jöreskog & Sörbom, 1993).

Table 3.2 Criteria of Fit Indices

Fit Index	Criterion
Chi-Square (χ^2)	Non-significant
Normed Chi-Square	NC < 5
Goodness of Fit Index (GFI)	GFI > 0.90
Adjusted Goodness of Fit Index (AGFI)	AGFI > 0.90
Root Mean Square Error of Approximation (RMSEA)	0.05 < RMSEA < 0.08 (moderate fit)
Root Mean Square Residual (RMR)	RMR < 0.05
Standardized Root Mean Square Residual (S-RMR)	S-RMR < 0.05

Table 3.2 (Continued)

Parsimony Goodness of Fit Index (PGFI)	Higher values
Parsimony Normed Fit Index (PNFI)	Higher values
Normed Fit Index (NFI)	NFI > 0.90
Non-Normed Fit Index (NNFI)	NNFI > 0.90
Comparative Fit Index (CFI)	CFI > 0.90
Incremental Fit Index (IFI)	IFI > 0.90
Relative Fit Index (RFI)	RFI > 0.90

3.4.3.3 Fitted Residuals and Standardized Residuals

Fitted residuals depend on the unit of measurement of the observed variables. Standardized residuals are independent of the units of measurement of the variables (Jöreskog & Sörbom, 1993). For every observed variable standardized residuals are calculated. Large standardized residuals that are above 2 indicate a lack of fit (Kelloway, 1998). This signifies that a specific covariance is not explained well by the model; hence the model should be assessed to determine ways in which this particular covariance could be explained (Schumacker & Lomax, 2004). Furthermore, when the model fits the data well, the fitted and standardized residuals for the model are typical and the two residual stem-leaf plots look approximately normal.

3.5 Ethical ssues

The data collected in this study consist of paper-pencil tests. Hence there was no possible harm to any of the participants of this study. Confidentiality of the data was guaranteed, and the participating students and teachers were ensured that any personal information would be protected in publications built on this research. Personal identifiable information was not gathered from any student during the research. Moreover, the participants were told that they could withdraw from the participation at any time.

Besides, the purpose of the research and the details about data collection process were explained to the participants. In addition, before the survey test and the derivative achievement test was administered, permission to collect data from the universities was taken from Rectorship of METU, the Graduate School of Natural and Applied Sciences, the Ethical Committee, and the Ministry of National Education, see Appendix G. Moreover, prior to the application of the survey and the derivative achievement test, consent forms (Appendix H) for students were prepared and students were asked to read and to sign the consent form before accepting to be participant in the study.

CHAPTER 4

RESULTS

In this chapter, the results of the present study are presented with the structural equation modeling. The aim of the analyses is to test the model which was constructed in the light of the literature. The hypothesized model is given in Figure 1.1. The model is constructed on the theoretical basis.

4.1 Results of Confirmatory Factor Analysis of the Affective Variables

Confirmatory factor analyses were conducted to identify latent variables of the ACQ. SES is measured in the demographic profiles questionnaire; however it is addressed with the affective variables. The latent variables were named as SES, MOTIV, TANX, SANX, and SELF; denoting socioeconomic status, motivation, test anxiety, social anxiety, and self-efficacy respectively. These observed variables were tested to fit five-factor model in the confirmatory analysis. After inspecting modification indices with higher values, by using SIMPLIX syntax of LISREL, error covariances of the suggested observed variables were noted and revisions were made by permitting errors of four pairs of observed variables to correlate. In order to improve the fit of the model, five error covariance were set free since as default the error terms are assumed to be uncorrelated by LISREL 8 (Jöreskog & Sörbom, 1993).

The final SIMPLIS syntax for the confirmatory factor analysis of the affective model was involved in Appendix I. The standardized solution of the parameter estimates and the t values of the structural model for the affective model are shown in Figures 4.1 and 4.2 respectively. In Figures 4.1 and 4.2 SES refers to socioeconomic status, MOTIV refers to motivation, TANX refers to test anxiety, SANX refers to social anxiety, and SELF refers to derivative self-efficacy.

The model is confirmed for four latent variables which were measured by 50 observed variables. The squared multiple correlations, R^2, for observed variables of the latent variables are presented in Table 4.1 and Table 4.2.

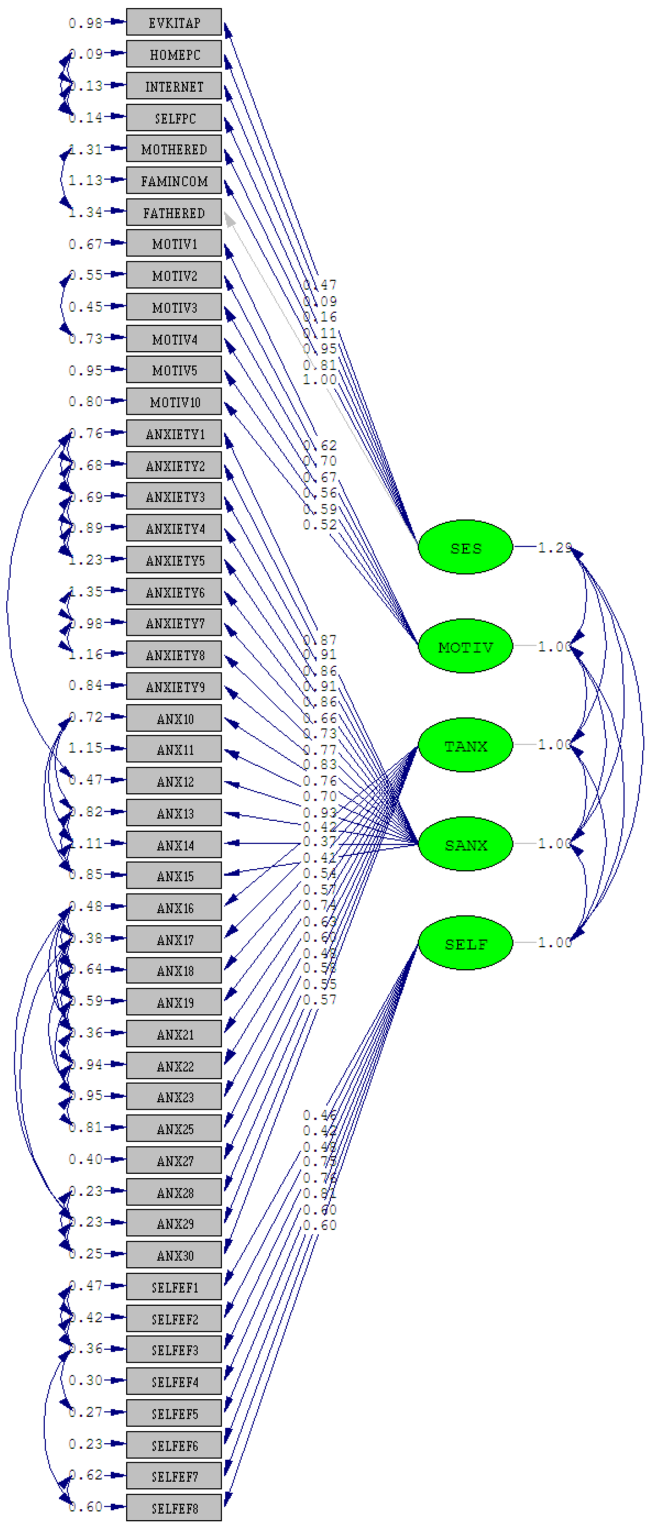

Figure 4.1 Standardized Parameter Estimates of the Affective Model

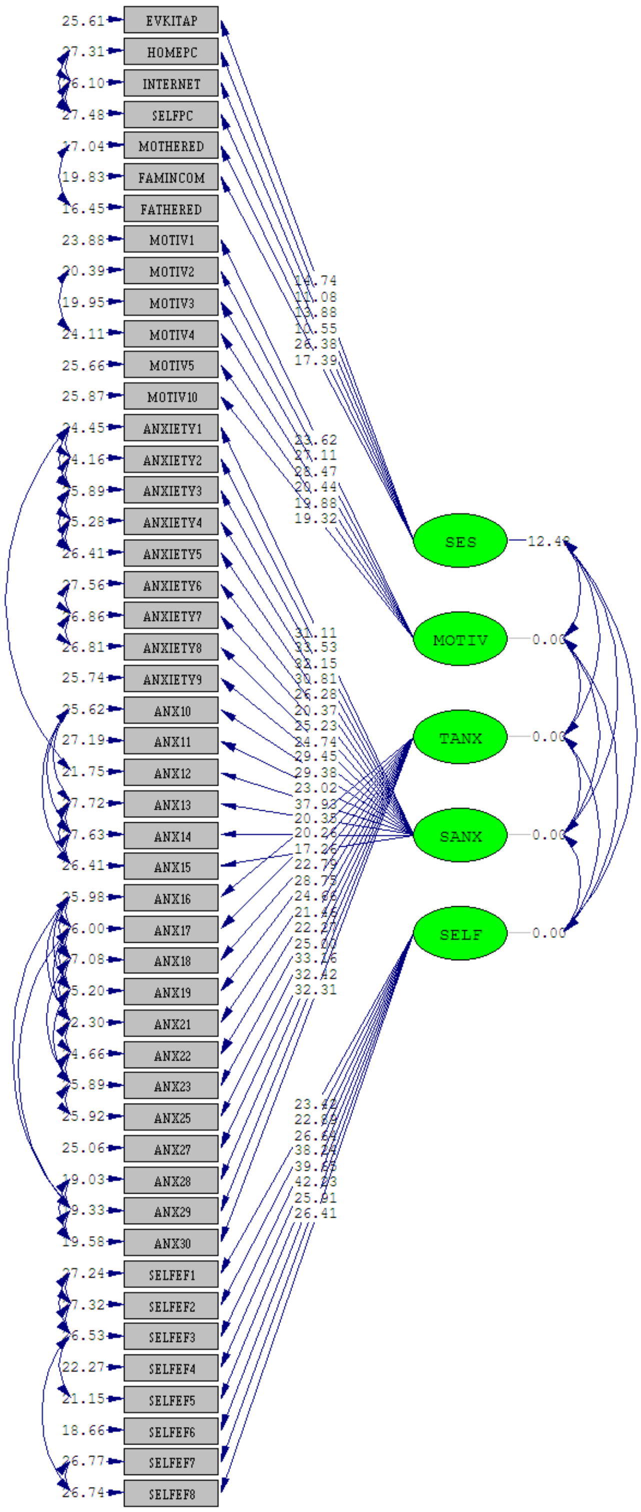

Figure 4.2 Parameter Estimates of the Affective Variables in T-values

Table 4.1 Squared Multiple Correlations for the Socioeconomic Status

Latent Variables	Observed Variables	Squared Multiple Correlation (R^2)
Socioeconomic status	Mothered	0.470
	Fathered	0.490
	Famincome	0.429
	Evkitap	0.229
	İnternet	0.198
	Homepc	0.117
	Selfpc	0.105

Table 4.2 Squared Multiple Correlations for the Affective Variables

Latent Variables	Observed Variables	Squared Multiple Correlation (R^2)
Social anxiety	anxiety2	0.546
	anxiety12	0.648
	anxiety3	0.516
	anxiety1	0.500
	anxiety4	0.482
	anxiety9	0.450
	anxiety10	0.450
	anxiety5	0.378
	anxiety15	0.374
	anxiety7	0.354
	anxiety8	0.342
	anxiety11	0.302
	anxiety6	0.246
	anxiety14	0.219
	anxiety13	0.206
Test anxiety	anxiety28	0.590
	anxiety30	0.569
	anxiety29	0.573
	anxiety 21	0.478
	anxiety19	0.329
	anxiety27	0.371
	anxiety22	0.371
	anxiety25	0.308
	anxiety23	0.296
	anxiety16	0.272

Table 4.2 (Continued)

	anxiety25	0.308
	anxiety23	0.296
	anxiety16	0.272
	anxiety17	0.270
	anxiety18	0.204
Self-Efficacy	self-efficacy6	0.742
	self-efficacy5	0.683
	self-efficacy4	0.650
	self-efficacy3	0.390
	self-efficacy8	0.377
	self-efficacy7	0.366
	self-efficacy1	0.310
	self-efficacy2	0.298
Motivation	motivation3	0.499
	motivation2	0.470
	motivation4	0.301
	motivation1	0.362
	motivation5	0.268
	motivation10	0.255

The measurement coefficients (λx) and their error variances (ε) in the λY variables for the affective model are presented in Appendix J.

The summary statistics for the CFA model of the survey test are presented in Appendix K. The steam and leaf plots and Q-plots of fitted and standardized residuals show that the model fits the data well. Besides, fitted residuals are within the range of 0.26 in absolute value. Hence the fitted residuals are considered as small in magnitude (Schumacker & Lomax, 2004). After suggested modification indices made, the fit indices of the test model are: [(χ^2 (2808.454, N = 1660) = 2708.695 p<.00. RMSEA= 0.0324. S-RMR = 0.0468. GFI =0.934. AGFI = 0.924. CFI =0.981, NNFI= 0.979]. Hence, the values obtained for the goodness of fit indices show that the model of the test fits the data very well. The acceptable range for the fit indices and their values for assessing the fit of the model are presented below in Table 4.3 (see Appendix L for range of fit indices in detail).

Table 4.3 Fit Indices and Values for the Model of the Affective Variables

Fit Index	Criterion	Value
Chi-Square (χ^2)	Ratio of χ^2 to df < 5	=2,64
Degrees of Freedom (df)		
Root Mean Square Error of Approximation (RMSEA)	< 0.05 smaller the better	0.0324

Table 4.3 (Continued)

Root Mean Square Residual (RMR)		0.0405
Standardized Root Mean Square Residual (S-RMR)		0.0468
Parsimony Goodness of Fit Index (PGFI)	higher the better	0.813
Parsimony Normed Fit Index (PNFI)		0.880
Normed Fit Index (NFI)	>0.90	0.970
Non-Normed Fit Index (NNFI)		0.979
Comparative Fit Index (CFI)		0.981
Incremental Fit Index (IFI)		0.981
Relative Fit Index (RFI)		0.967
Goodness of Fit Index (GFI)		0.934
Adjusted Goodness of Fit Index (AGFI)		0.924

4.2 Results of Confirmatory Factor Analysis of the Prerequisite Test

To identify latent variables of the prerequisite test, confirmatory factor analysis was conducted. The prerequisite test is the first part of the DAT which can be seen in Appendix F from question 1 to question 17. The latent variables were named as PRET (retrieval cognitive level of prerequisite knowledge), PCOMP (comprehension cognitive level of prerequisite knowledge), PANLYS (analysis cognitive level of prerequisite knowledge), and PKU (knowledge utilization cognitive level of prerequisite knowledge) denoting retrieval cognitive domain of prerequisite knowledge, comprehension cognitive domain of prerequisite knowledge, analysis cognitive domain of prerequisite knowledge, and knowledge utilization cognitive domain of prerequisite knowledge respectively. These observed variables were tested to fit four-factor model in the confirmatory analysis. With the SIMPLIX syntax of LISREL, modification indices with higher values are inspected, error covariance of the suggested observed variables were recorded and revisions were made by permitting errors of four pairs of observed variables to correlate. To improve the fit of the model, five error covariance were set free since as default the error terms are assumed to be uncorrelated by LISREL 8 (Jöreskog & Sörbom, 1993). The questions of the prerequisite test appeared in the results can be seen in Appendix M.

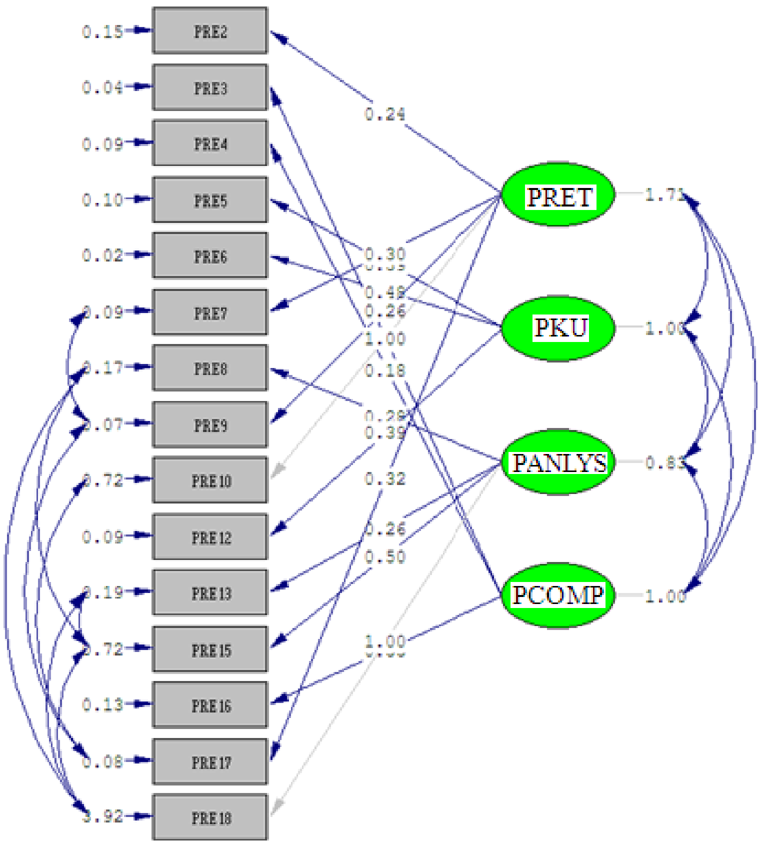

Figure 4.3 Standardized Parameter Estimates of the Prerequisite Model

The final SIMPLIS syntax of the confirmatory factor analysis of the test can be seen in Appendix N. The standardized solution of the parameter estimates and the t values of the structural model for the test are shown in Figures 4.3 and 4.4 respectively.

The model of the test was confirmed for 3 latent variables which were measured by 12 observed variables. The squared multiple correlations R^2 for specified observed variables of the latent variables can be seen in Table 4.4.

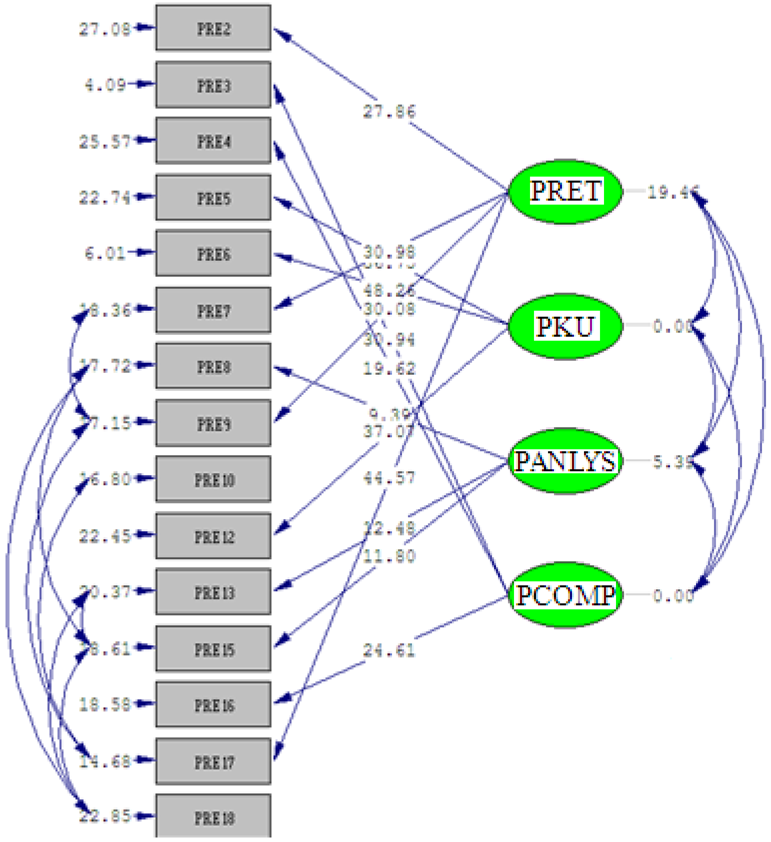

Figure 4.4 Parameter Estimates of the Prerequisite Test in T-values

Table 4.4 Squared Multiple Correlations for the Prerequisite Test

Latent Variables	Observed Variables	Squared Multiple Correlation (R^2)
Pre-Retrieval	prerequisite17	0.685
	prerequisite9	0.625
	prerequisite7	0.623
	prerequisite2	0.400
Pre-Knowledge Utilization	prerequisite6	0.908
	prerequisite12	0.628
	prerequisite5	0.619
Pre-Analysis	prerequisite8	0.269
	prerequisite13	0.223
	prerequisite15	0.219
Pre-Comprehension	prerequisite3	0.830
	prerequisite16	0.452
	prerequisite4	0.265

The measurement coefficients (λx) and their error variances (ε) in the λY variables were listed in Table 4.5 below:

Table 4.5 Measurement Coefficients and Error Variances for the Prerequisite Test

Latent Variables	Observed Variables	λx	δ
Pre-Retrieval	prerequisite17	0.315	0.078
	prerequisite7	0.296	0.091
	prerequisite9	0.261	0.069
	prerequisite2	0.240	0.148
Pre-Knowledge Utilization	prerequisite6	0.476	0.023
	prerequisite12	0.395	0.092
	prerequisite5	0.393	0.095
Pre-Analysis	prerequisite15	0.495	0.720
	prerequisite8	0.279	0.175
	prerequisite13	0.257	0.190
Pre-Comprehension	prerequisite3	0.419	0.036
	prerequisite16	0.332	0.134
	prerequisite4	0.180	0.090

The summary statistics for the CFA model of the prerequisite test are presented in Appendix O. The steam and leaf plots and Q-plots of both fitted and standardized residuals show that the model fits the data well. In addition, fitted residuals within the range of 0.13 in absolute value and are considered as small in magnitude (Schumacker & Lomax, 2004). The fit indices of the model after freeing some of the parameters are: ([(χ^2=251.816, N = 1660) p<.0000. RMSEA= 0.0373, S-RMR = 0.0306, GFI =0.980, AGFI = 0.969, CFI =0.988, NNFI= 0. 983]. Thus, the values obtained as goodness of fit indices indicate that the tested model gave fit to the data. The acceptable range for the fit indices and their values for assessing the fit of the model were given below in Table 4.6 (see Appendix P for range of fit indices in detail).

Table 4.6 Fit Indices and Values for the model of the Prerequisite Test

Fit Index	Criterion	Value
Chi-Square (χ^2)	Ratio of χ^2 to df < 5	=3,31
Degrees of Freedom (df)		
Root Mean Square Error of Approximation (RMSEA)	< 0.05 smaller the better	0.0373
Root Mean Square Residual (RMR)		0.0167
Standardized Root Mean Square Residual (S-RMR)		0.0306
Parsimony Goodness of Fit Index (PGFI)	higher the better	0.621
Parsimony Normed Fit Index (PNFI)		0.711

Table 4.6 (Continued)

Normed Fit Index (NFI)	>0.90	0.983
Non-Normed Fit Index (NNFI)		0.983
Comparative Fit Index (CFI)		0.988
Incremental Fit Index (IFI)		0.988
Relative Fit Index (RFI)		0.976
Goodness of Fit Index (GFI)		0.980
Adjusted Goodness of Fit Index (AGFI)		0.969

4.3 Results of Confirmatory Factor Analysis of the Derivative Test

Confirmatory factor analysis was conducted to identify latent variables of the derivative test. The questions of the derivative test appeared in the results can be seen in Appendix M.The latent variables were named as DRET (retrieval cognitive skill of derivative), DCOMP (comprehension cognitive skill of derivative), DANLYS (analysis cognitive skill of derivative), and DKU (knowledge utilization cognitive skill of derivative). These observed variables were tested to fit four-factor model in the confirmatory analysis. By using SIMPLIX syntax of LISREL, after inspecting modification indices with higher values, error covariances of the suggested observed variables were noted and revision was done by permitting errors of one pair of observed variables to correlate. In order to improve the fit of the model, five error covariances were set free since as default the error terms are assumed to be uncorrelated by LISREL 8 (Jöreskog & Sörbom, 1993).

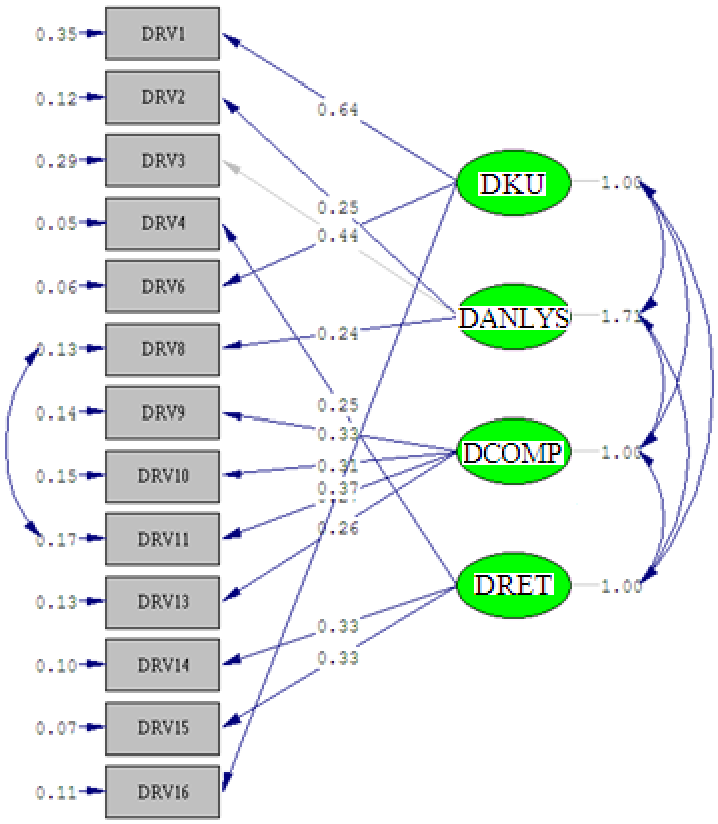

Figure 4.5 Standardized Parameter Estimates of the Derivative Test

By using SIMPLIX syntax of LISREL, after inspecting modification indices with higher values, error covariances of the suggested observed variables were noted and revision was done by permitting errors of one pair of observed variables to correlate. In order to improve the fit of the model, one error covariance was set free since as default the error terms are assumed to be uncorrelated by LISREL 8 (Jöreskog & Sörbom, 1993). The final SIMPLIS syntax for the confirmatory factor analysis of the derivative test was included in Appendix Q. The standardized solution of the parameter estimates and the t values of the structural model for the test are shown in Figures 4.5 and 4.6 respectively.

The model of the test was approved for 3 latent variables that were measured by 9 observed variables. The squared multiple correlations R^2 for specified observed variables of the latent variables were given in Table 4.7.

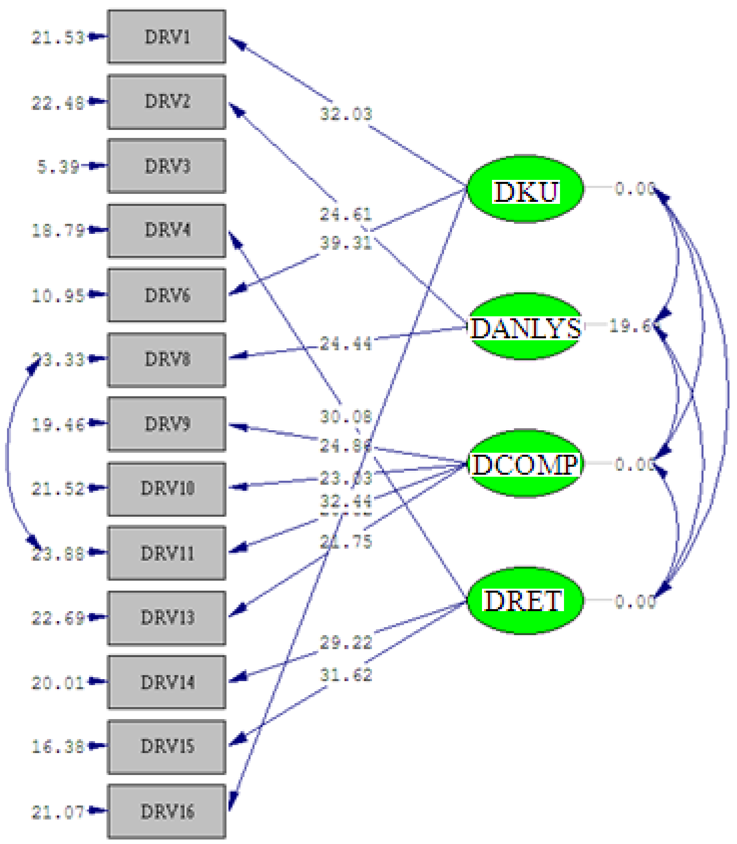

Figure 4.6 Parameter Estimates of the Derivative Test in T-values

Table 4.7 Squared Multiple Correlations for the Derivative Test

Latent Variables	Observed Variables	Squared Multiple Correlation (R^2)
Derivative Knowledge Utilization	derivative6	0.768
	derivative16	0.556
	derivative1	0.544
Derivative Analysis	derivative3	0.854
	derivative2	0.469
	derivative8	0.441
Derivative Comprehension	derivative9	0.444
	derivative10	0.384
	derivative13	0.345
	derivative11	0.300
Derivative Retrieval	derivative15	0.596
	derivative4	0.541
	derivative14	0.512

The measurement coefficients (λx) and their error variances (ε) in the λY variables were listed in Table 4.8 below:

Table 4.8 Measurement Coefficients and Error Variances for the Derivative Test

Latent Variables	Observed Variables	λx	δ
Derivative Knowledge Utilization	derivative1	0.642	0.346
	derivative16	0.372	0.111
	derivative6	0.437	0.058
Derivative Analysis	derivative3	0.788	0.293
	derivative2	0.248	0.119
	derivative8	0.244	0.129
Derivative Comprehension	derivative9	0.331	0.137
	derivative10	0.310	0.154
	derivative11	0.269	0.169
	derivative13	0.264	0.133
Derivative Retrieval	derivative15	0.331	0.074
	derivative14	0.330	0.104
	derivative4	0.253	0.054

The summary statistics for the CFA model of the test were given in Appendix R. The steam and leaf plots and Q-plots of both fitted and standardized residuals show that the model fits the data well. In addition, fitted residuals within the range of 0.05 in absolute value and are considered as small in magnitude (Schumacker & Lomax, 2004). The fit indices of the model after freeing some of the parameters are: [(χ^2=189.559, N = 1660, p<.0000. RMSEA= 0.0367, S-RMR = 0.0330, GFI = 0.983, AGFI = 0.973, CFI =0.983, NNFI= 0.978]. Thus, the values obtained as goodness of fit indices show that the model of the test fits the data very well. The acceptable range for the fit indices and their values for assessing the fit of the model were given below in Table 4.9 (see Appendix S for range of fit indices in detail).

Table 4.9 Fit Indices and Values for the model of the Test

Fit Index	Criterion	Value
Chi-Square (χ^2)	Ratio of χ^2 to df < 5	=3,268
Degrees of Freedom (df)		
Root Mean Square Error of Approximation (RMSEA)	< 0.05 smaller the better	0.0367
Root Mean Square Residual (RMR)		0.0114
Standardized Root Mean Square Residual (S-RMR)		0.0330
Parsimony Goodness of Fit Index (PGFI)	higher the better	0.626
Parsimony Normed Fit Index (PNFI)		0.726

Table 4.9 (Continued)

Normed Fit Index (NFI)	>0.90	0.976
Non-Normed Fit Index (NNFI)		0.978
Comparative Fit Index (CFI)		0.983
Incremental Fit Index (IFI)		0.983
Relative Fit Index (RFI)		0.968
Goodness of Fit Index (GFI)		0.983
Adjusted Goodness of Fit Index (AGFI)		0.973

4.4 Structural Equation Modeling: The Derivative Model

According to the results of the factor analyses the observed variables that represent the latent variables were determined and and hypothesized model was tested. The data file containing all the variables in this study was imported into PRELIS 2.71 for Windows. The necessary steps of LISREL 8.71 for Windows with SIMPLIS command language were carried out for formulating and estimating the structural equation model. In LISREL package program, SIMPLIS provides command language and PRELIS provides getting the covariance matrix. The structural equation modeling analyses were conducted by using Maximum Likelihood Method of Estimation. In the analysis of this study, the significance level was chosen to be 0.05.

The initial model was given in Figure 1.1 in Chapter 1. It was hypothesized that there would be relationships among the variables concerning four types of cognitive levels of the derivative knowledge and its prerequisite knowledge. Moreover relationships between student related factors and prerequisite knowledge of derivative are tested. This model was tested with four types of cognitive levels of the derivative knowledge and its prerequisite knowledge and twenty-six covariance terms were added to SIMPLIS syntax in order to improve the model. The model improvement was carried out by inspecting the modification indices. The final SIMPLIS syntax for the Derivative Model is given in Appendix T.

While the non-significant relations were not incuded in the model, Figure 4.7 indicates standardized path coefficients, and Figure 4.8 indicates t values of the path coefficients. Moreover, LISREL estimates of parameters in the final model with coefficients in standardized value and t-values are represented in Appendix U. The Beta values denoting the coefficients among the derivative achievement in retrieval, comprehension, analysis, and knowledge utilization cognitive domains and the t-values are presented in Table 4.10. Besides, the Gamma values denoting the strength and direction of the dependent and independent variables and the t values are presented in Table 4.11. Therefore, the structural modeling of university students' derivative achievements can be seen in Table 4.10, Table 4.11 and Figure 4.7.

Table 4.10 Beta Path Coefficients of the Derivative Model

Latent variables	Beta	t
DCOMP-DRET	0.19	4.98
DKU-DANLYS	0.05	1.96
DKU-DRET	0.01	0.43
DANLYS-DRET	0.01	0.31

Table 4.11 Gamma Path Coefficients of the Derivative Model

		Gamma	t
SES	PRET	0.029	0.604
SELF		0.014	0.313
MOTIV		- 0.064	-1.598
SES	PCOMP	0.131	4.250
SELF		0.042	1.690
MOTIV		0.032	1.307
SANX		- 0.013	-0.501
SANX	PANLYS	0.097	2.026
SES		0.076	1.535
SELF		0.055	1.173
TANX		- 0.107	-2.456
PRET	DRET	0.117	5.246
PCOMP		0.071	2.694
PANLYS		0.071	3.259
PKU	DCOMP	0.632	9.783
PCOMP		0.070	2.214
PANLYS		- 0.190	-4.308
PRET	DANLYS	0.178	6.461
PANLYS		0.076	2.875
PKU	DKU	0.210	1.963
PANLYS		0.192	0.848
PRET		0.117	0.267
PCOMP		0.056	2.299

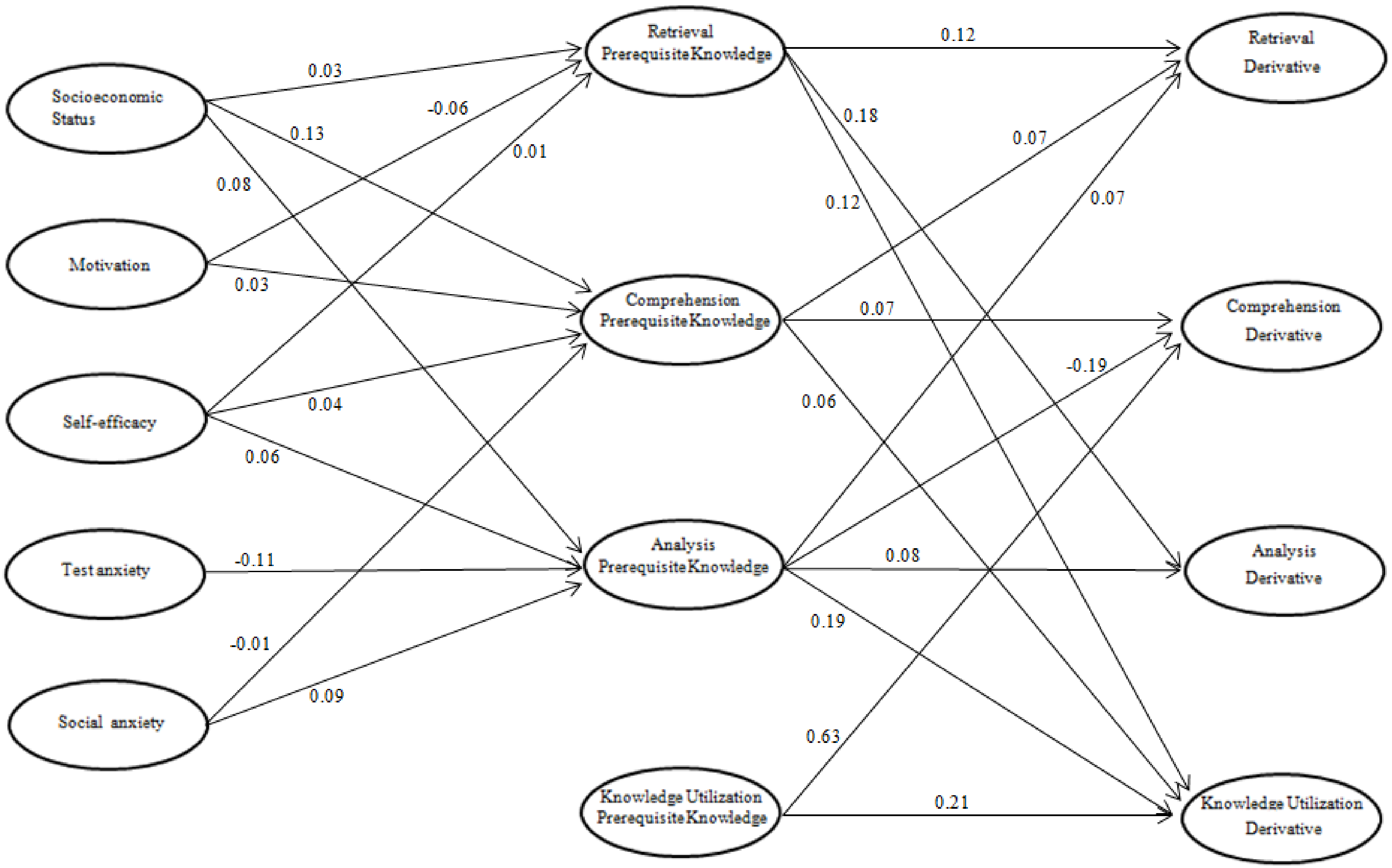

Figure 4.7 Parameter Estimates of the Derivative Model in Standardized Values

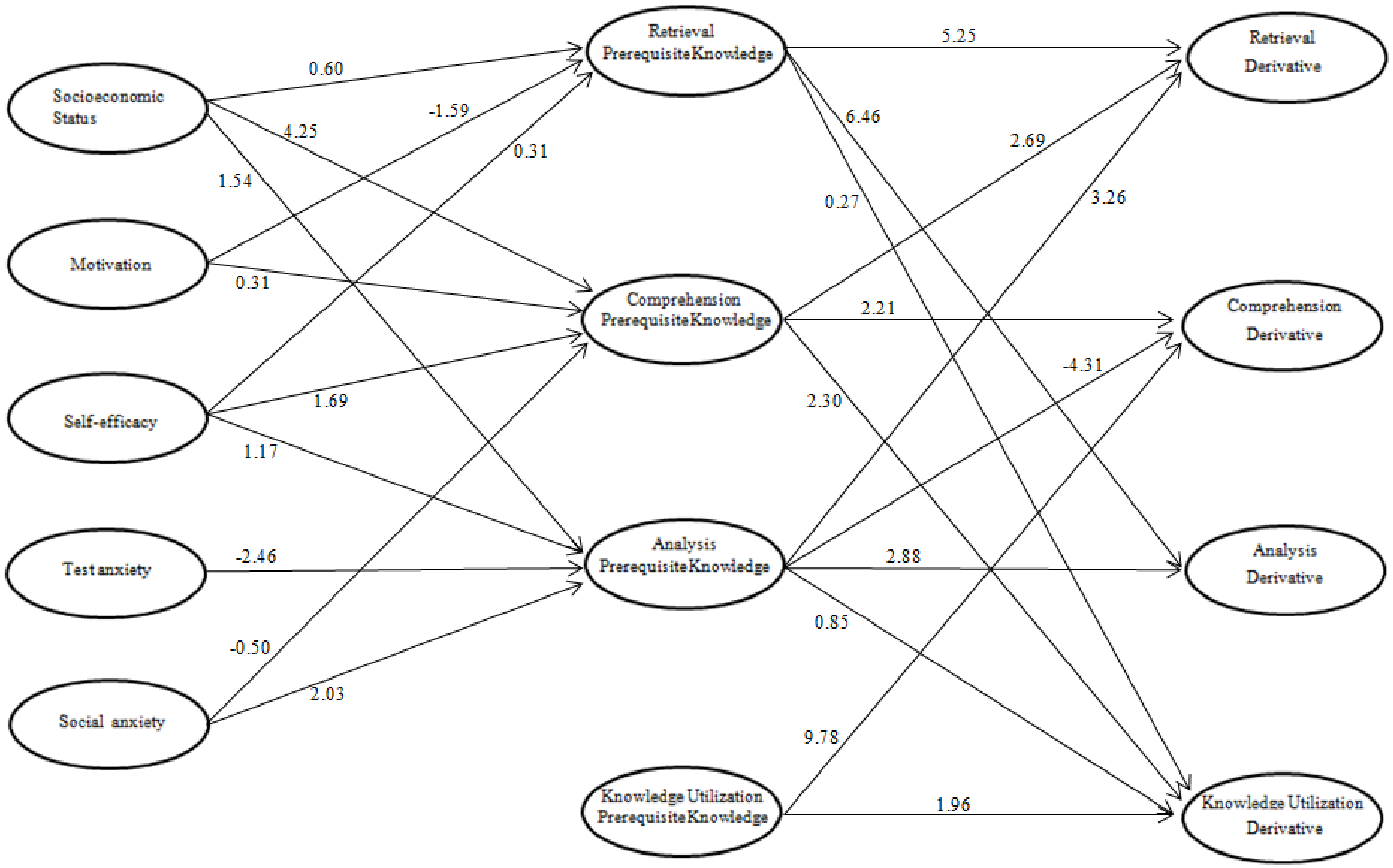

Figure 4.8 Parameter Estimates of the Derivative Model in t-values

The summary statistics which were given in Appendix V show that fitted residuals range are between the acceptable values for a good fit which is ±1 (Kelloway, 1998). The goodness of fit indices after the revision according to the modification indices are: [χ^2 (5765.118, N = 1660), p<.00, RMSEA= 0.0283, S-RMR = 0.0406, GFI = 0.911, AGFI = 0.903, CFI = 0.971, NNFI= 0.969]. It can be observed that the data give a good fit to the model and the coefficients among the latent variables vary between -0.21 and 0.62. The goodness of fit indices are given in Table 4.12 below:

Table 4.12 Goodness of Fit Indices of the Derivative Model

Fit Index	Criterion	Value
Chi-Square (χ^2)		
Degrees of Freedom (df)	Ratio of χ^2 to df < 5	=2,219
Table 4.12 (Continued)		
Root Mean Square Error of Approximation (RMSEA)	< 0.05 smaller the better	0.0283
Root Mean Square Residual (RMR)		0.0365
Standardized Root Mean Square Residual (S-RMR)		0.0406
Parsimony Goodness of Fit Index (PGFI)	higher the better	0.830
Parsimony Normed Fit Index (PNFI)		0.887
Normed Fit Index (NFI)	>0.90	0.948
Non-Normed Fit Index (NNFI)		0.969
Comparative Fit Index (CFI)		0.971
Incremental Fit Index (IFI)		0.971
Relative Fit Index (RFI)		0.944
Goodness of Fit Index (GFI)		0.911
Adjusted Goodness of Fit Index (AGFI)		0.903

For the standardized coefficients, the values below 0.10 denote a small effect, the values around 0.30 denote a medium effect, and the values around 0.50 and above denote a large effect (Kline, 1988). According to these criteria, the coefficient from knowledge utilization prerequisite latent variable to retrieval latent variable denotes a large effect. Moreover, the coefficients from retrieval prerequisite latent variable to retrieval latent variable; analysis prerequisite latent variable to comprehension latent variable; retrieval prerequisite latent variable to analysis latent variable; retrieval prerequisite latent variable to knowledge utilization latent variable; analysis prerequisite latent variable to knowledge utilization latent variable, and finally knowledge utilization prerequisite latent variable to knowledge utilization latent variable denote a medium or small to medium relation. Moreover the coefficients from comprehension prerequisite latent variable to retrieval latent variable; analysis prerequisite latent variable to retrieval latent variable; comprehension prerequisite latent variable to comprehension latent variable; analysis prerequisite latent variable to analysis latent variable; comprehension prerequisite latent variable to retrieval latent variable denote a small relation.

Furthermore, in LISREL for each endogenous variable in the model R^2 values are computed and accordingly interpreted in the sense of R^2 values in regression. The effect sizes in measures of squared multiple correlations for endogenous variables for the current study are presented in Table 4.13.

Table 4.13 Effect Sizes of the Derivative Model in R^2

Endogenous Variables	R^2
DCOMP	0.61
DKU	0.18
DANLYS	0.09
DRET	0.07

In the model tested, 61 percent of the variance on comprehension subdomain was explained by the exogeneous variables. Similarly, the total variance explained on the knowledge utilization cognitive domain of derivative achievement is 18 percent. On the other hand, 9 percent of the variance on analysis subdomain and 7 percent of the variance on retrieval subdomain was explained by the exogeneous variables.

In the derived model, when each of the endogeneous variables taken into consideration; for the retrieval subdomain, the greatest relation was found coming from the retrieval prerequisite latent variable. For the comprehension, the greatest relation was found with the knowledge utilization prerequisite latent variable. Moreover, for the analysis subdomain, the largest relation was found as coming from the retrieval prerequisite latent variable. Similarly, the largest relation on the knowledge utilization subdomain is knowledge utilization prerequisite latent variable and analysis prerequisite latent variable.

On the other hand the relations among comprehension prerequisite latent variable, analysis prerequisite latent variable and retrieval latent variable are comparatively smaller. The relations among comprehension prerequisite latent variable and comprehension latent variable are also small. Likewise small relations are observed among analysis prerequisite latent variable and analysis cognitive level of derivative. Finally, the relations between comprehension cognitive level of prerequisite knowledge and knowledge utilization cognitive level of derivative are determined to be small.

A negative relationship is observed in between the analysis cognitive level of prerequisite knowledge and comprehension cognitive level of derivative. On the other hand, rest of the relationships observed between the cognitive levels of prerequisite knowledge and the cognitive levels of derivative are in positive direction. As expected, as students' cognitive levels of prerequisite knowledge increase, their cognitive levels of derivative also increase. Inversely as students' analysis cognitive level of prerequisite knowledge increases, their comprehension cognitive level of derivative decreases.

There is a large relationship between knowledge utilization cognitive level of prerequisite knowledge and comprehension cognitive level of derivative in the positive direction. This value shows that as students' knowledge utilization cognitive level of prerequisite knowledge increases, their comprehension cognitive level of derivative also necessarily increases. Moreover the partially medium relationship from retrieval cognitive level of prerequisite knowledge to retrieval cognitive level of derivative shows that as students' retrieval cognitive level of prerequisite knowledge increases, their retrieval cognitive level of derivative also increases. The negative medium relationship from analysis cognitive level of prerequisite knowledge to comprehension cognitive level of derivative indicates as students' analysis cognitive level of prerequisite knowledge increases their comprehension cognitive level of derivative decreases. The medium relationship from retrieval cognitive level of prerequisite knowledge to analysis cognitive level of derivative shows that students' retrieval cognitive level of prerequisite knowledge increases as their analysis cognitive level of derivative increases. In the same manner the medium and positive relationship from retrieval cognitive level of prerequisite knowledge to knowledge utilization cognitive level of derivative indicates that as students are better equipped in retrieval cognitive levels of prerequisite knowledge, their knowledge utilization cognitive level of derivative increase. Moreover, again denoting positive medium relations between analysis cognitive level of prerequisite knowledge, knowledge utilization cognitive level of prerequisite knowledge and knowledge utilization cognitive level of derivative with the values of 0.19 and 0.21 respectively is observed in the model. This fact shows that as analysis cognitive level of prerequisite knowledge or knowledge utilization cognitive level of prerequisite knowledge increases, knowledge utilization cognitive level of derivative also increases.

When the affective variable of the students were taken into account, the greatest relation was found between comprehension cognitive skills of the prerequisite knowledge and socioeconomic status. The largest relation on the retrieval cognitive skill of the prerequisite knowledge was found to come from socioeconomic status. Moreover, the largest relations on the analysis cognitive skills of the prerequisite knowledge are found to come from socioeconomic status and social anxiety. Besides, there has been no relation of student related factors found on knowledge utilization cognitive level of prerequisite knowledge. While the relations are mentioned as the largest ones, most of them are small relations. Only the relation from socioeconomic status to comprehension cognitive level of prerequisite knowledge and the relation from social anxiety to analysis cognitive level of prerequisite knowledge are nearly medium.

Positive relationships are observed in between socioeconomic status, self-efficacy and retrieval cognitive level of prerequisite knowledge. The relationships observed between socioeconomic status, self-efficacy, motivation and comprehension cognitive level of prerequisite knowledge are in the positive direction. Moreover, the relationships observed between self-efficacy, socioeconomic status, social anxiety and analysis cognitive level of prerequisite knowledge are in positive direction. On the other hand, the relationship between motivation and retrieval cognitive level of prerequisite knowledge is observed to be in negative direction. The relationship among social anxiety and comprehension cognitive skill of prerequisite knowledge is also in the negative direction. Finally the relationship between test anxiety and analysis cognitive skill of prerequisite knowledge is observed to be in the negative direction.

Specifically, the positive relationships were observed between socioeconomic status and retrieval, comprehension and analysis cognitive levels of prerequisite knowledge. As expected, as students' socioeconomic status increases, their prerequisite knowledge also increases in the mentioned cognitive levels. Likewise, students' self-efficacy has positive relationships with the retrieval, comprehension and analysis cognitive levels of prerequisite knowledge. This also means that as students' self-efficacy increases, their success in prerequisite knowledge also increases.

An interesting finding of the study is about the motivation subdimension. As students' motivation increases their retrieval cognitive level of prerequisite knowledge decreases. However as students' motivation increases, their comprehension cognitive level of prerequisite knowledge also increases. On the other hand social anxiety increases comprehension cognitive level of prerequisite knowledge decreases. Besides as social anxiety increases, analysis cognitive level of prerequisite knowledge decreases. Finally as test anxiety increases, analysis cognitive level of prerequisite knowledge decreases.

The values of the measurement coefficients as the λ^y (lowercase lambda sub y) and the λ^x (lowercase lambda sub x) indicate the relationships between the latent variables and the observed variables. Furthermore, the ε (lowercase epsilon) and δ (lowercase delta) are the measurement errors for the Ys and Xs, respectively. The measurement and error coefficients of the Derivative Model were given in standardized values in Appendix W.

In LISREL output, the squared multiple correlation (R^2) for each variable was also displayed. This measurement gives the proportion of the explained variance. For example, a value of 0.40 means that 40 % of the variance of a variable is explained by another variable. In Appendix X, the squared multiple correlations (R^2) of the observed variables are represented. Moreover, the structural regression equations of the Derivative Model are given in Appendix Y.

The values of fit indices of the model meet the required cut-off criteria. Additionally, the normal shape steam and leaf plots and Q-plots of the fitted residuals and their range are within 1 in absolute value. Besides, the similarity of the shape of the steam and leaf plots of fitted residuals to the standardized residuals also refer to an overall fit of the data to the model.

This study investigated to test the model given in Figure 1.1. Through the use of structural equation modeling, the mentioned model gave sufficient fit regarding goodness-of-fit (GFI) and adjusted goodness-of-fit (AGFI) indexes, and the root mean square error of approximation (RMSEA) index. Finally with the results presented, it can be concluded that the Derivative Model indicated a good fit to the data.

CHAPTER 5

DISCUSSION, CONCLUSION AND IMPLICATIONS

In this chapter the discussion and the conclusion of the results, the interpretations of the findings, educational implications, and recommendations for future research are presented.

5.1 Discussion of the Results

The review of the related literature indicates that, up to now very little research has been conducted including university students' derivative knowledge and its prerequisite knowledge with the consideration of cognitive levels. The present study investigated to test the model given in Figure 1.1. The relationships among a set of prerequisite and derivative knowledge variables and student related factors were explained through the confirmatory factor analysis. Finally the Derivative Model indicated a good fit to the data in the current study.

The purpose of this study was to test whether the hypothesized model explains students' achievement of the derivative concept. The summary results for the tested model with respect to the standardized path coefficients and their ranges, and the effect sizes for each latent dependent variable are depicted in the previous chapter. Standardized path coefficients with absolute values less than 0.10 are considered as having a small effect, the values around 0.30 are regarded as medium and values above 0.50 indicate large effect sizes (Kline, 1998). In addition, effect sizes are classified as follows in terms of multiple correlation coefficients; the values up to 0.01 indicate small, the values around 0.09 show medium and the values above than 0.25 indicate large effect sizes according to Cohen's work (1988) (cited in Kline, 1998).

As seen in Table 4.13, considering the effect sizes which were denoted by the latent dependent variable retrieval cognitive level of derivative (DRET), analysis cognitive level of derivative (DANLYS), and knowledge utilization cognitive level of derivative (DKU), have small to medium effect size for the tested model. On the other hand, the latent dependent variable of comprehension cognitive level of derivative (DCOMP) has large effect size for the tested model. In social studies, in general small to medium effect sizes emerge (Weinfurt, 1995). According to the effect size measures of the model, the impact of comprehension cognitive level of derivative is very important for the derivative achievement. For the tested Derivative Model, 61 % of the total variance explained on comprehension; 18 % of the total variance explained on knowledge utilization; 9 % of the total variance explained on analysis and 7 % of the total variance explained on retrieval cognitive domains of derivative achievement. While obtaining small to medium effect sizes for this study is an expected outcome, the comprehension cognitive domain of the derivative achievement has a large relation. In this study, the comprehension cognitive domain of the derivative includes integrating and symbolizing the derivative. That is; identifying critical or essential elements of the differentiable functions and depicting the critical aspects of the derivative symbols and different forms of the limit definition of derivative. Hence it can be concluded that determination of the critical knowledge of differentiable functions and the effective use of symbols and limit definition of derivative is a very important aspect for the derivative achievement. Students encounter more cases of symbolic representation of derivative in general which may be an explanation for the mentioned finding. The importance of symbol use and the limit definition of derivative are also in line with the literature (Orton, 1983).

Moreover the relations of knowledge utilization and the analysis cognitive domain of the derivative are found to be medium. The analysis cognitive domain of derivative includes forming conclusions of real life applications for derivative such as interpreting graphs and instantaneous rate of change. Besides, making inferences for the function from the graph of a derivative function is also included in the analysis cognitive domain of derivative. Additionally the knowledge utilization of derivative includes developing a strategy to solve minimum/maximum problems, drawing the graph of a function with derivative knowledge and generating the tangent line from secant lines. When we consider the mentioned cognitive skills, the medium relations of the analysis and knowledge utilization cognitive skills can be explained. Acquiring these cognitive skills is the desired goal in derivative teaching. Hence the importance of these cognitive skills for the derivative achievement is obvious.

In this study, the largest relationship was from knowledge utilization cognitive level of the prerequisite knowledge to the comprehension cognitive skill of the derivative. The knowledge utilization cognitive level of the prerequisite knowledge includes making decisions for the limit of the secant lines and solving problems of limit of a series and functions with restricted conditions. This finding shows that as students have a working prerequisite knowledge; they are more successful in comprehending the derivative knowledge. That is the utilizing of the prerequisite knowledge is very important for determination of the critical knowledge of differentiable functions and the effective use of symbols and limit definition of derivative. Taking this finding into account with the fact that the largest relation was of the comprehension cognitive level of derivative, the importance of the knowledge utilization cognitive level of prerequisite knowledge is obvious.

On the other hand, there has been observed a medium relationship in the negative direction from analysis cognitive skill of prerequisite knowledge to comprehension cognitive skill of derivative. This means that as students analysis cognitive skill of prerequisite knowledge increases their comprehension cognitive skill of derivative decreases. Analysis cognitive skill of prerequisite knowledge includes the cognitive skills of discriminating the piecewise functions, identifying dependent and independent variables in problems, diagnosing and editing indeterminate limits, and making conclusions of the rate of change from the graph of a function. This finding demonstrates the fact that as students can analyse prerequisite knowledge more, their comprehension cognitive skill of the derivative knowledge is not supported which includes determiniation of the critical knowledge of differentiable functions and the effective use of symbols. This finding indicates that as students analyse more in prereqisite knowledge, their symbol use in derivative or integration of the derivative representations is not supported.

Moreover, the positive medium relationship from knowledge utilization cognitive skill of prerequisite knowledge to knowledge utilization cognitive skill of derivative is also another important finding of the study. The knowledge utilization cognitive level of the prerequisite knowledge is about making decisions for the limit of the secant lines and solving problems of limit of a series and functions with restricted conditions. Besides, the knowledge utilization of derivative includes developing a strategy to solve minimum/maximum problems, drawing the graph of a function with derivative knowledge and generating the tangent line from the secant lines. Utilization of the knowledge of derivative is the desired goal for students' derivative achievement. Hence the mentioned finding shows that as students have a working prerequisite knowledge, they are more successful in utilizing knowledge in the derivative knowledge.

Besides, there has been determined a nearly medium positive relationship from analysis cognitive skill of prerequisite knowledge to knowledge utilization cognitive skill of derivative. Analysis cognitive level of prerequisite knowledge includes the skills of discriminating the piecewise functions, identifying dependent and independent variables in problems, diagnosing and editing indeterminate limits, and making conclusions of the rate of change from the graph of a function. This cognitive skill of the prerequisite knowledge supports students' utilization of knowledge in derivative. This finding is in line with the previous research literature that, the more analysis and generalizations students make on prerequisite knowledge, the more they utilize knowledge in the derivative (Ferrini-Mundy & Lauten, 1993).

There is a medium relationship from retrieval cognitive level of prerequisite knowledge to analysis cognitive level of derivative. Retrieval cognitive level of prerequisite knowledge is about determining the degree of a polynomial, determining the intersection points of a graph to the axes, making simple simplification operations and demonstrating secong degree equations. The analysis cognitive domain of derivative includes forming conclusions of real life applications for derivative such as interpreting graphs and instantaneous rate of change. This finding shows that students' analysis skills of derivative is suported with their retrieval skills of the prerequisite knowledge. In other words, as students are more competend in retrieving, recalling, or executing the prerequisite knowledge, they are better equipped with analysing and generalizing the derivative knowledge.

Retrieval cognitive level includes mainly executing the prerequisite knowledge. In this level students are not expected to demonstrate the knowledge in depth. Retrieval cognitive level of prerequisite knowledge includes determining the degree of a polynomial, determining the intersection points of a graph to the xy-axes, making simple simplification operations and demonstrating secong degree equations. Retrieval cognitive level of derivative includes applications of simple derivative taking rules and recalling that the derivative of the minima and maxima of a function is zero. The positive and nearly medium relationship from retrieval cognitive level of prerequisite knowledge to retrieval cognitive level of derivative make it clear that as students get more equipped with the execution of prerequisite knowledge, they become more competent in taking the derivative and recalling simple derivative interpretations. The support of the retrieval cognitive skill of the prerequisite knowledge on the retrieval cognitive level of the derivative knowledge is an expected outcome of the study. This finding is supported with the findings of some previous research (Habre & Abboud, 2006; Orton, 1983, Pillay, 2008) that students should have a competency of recognizing or executing knowledge in prerequisite knowledge to be competent in recognizing or executing knowledge in derivative concept.

There is a medium relationship from retrieval cognitive level of prerequisite knowledge to knowledge utilization cognitive level of derivative in positive direction. While retrieval cognitive level of prerequisite knowledge is about recalling and executing prerequisite knowledge, knowledge utilization cognitive level of the prerequisite knowledge includes making decisions for the limit of the secant lines and solving problems of limit of a series and functions with restricted conditions. This relationship indicates that as students can recall and execute prerequisite knowledge, they can utilize the derivative knowledge better.

The model emerged in the study indicates that all the four cognitive levels of prerequisite knowledge has relationships with knowledge utilization cognitive level of derivative. Knowledge utilization is the desired goal in derivative teaching. This finding demonstrates that for students to have a working knowledge of derivative if they can use the prerequisite knowledge in all the cognitive levels coherently. Hence it is very important to first have the working network of prerequisite knowledge to finally be more successful in knowledge utilization in derivative. Moreover, comprehension cognitive level of prerequisite knowledge has relationships with all of the four cognitive levels of the derivative. This finding indicates the importance of the comprehension cognitive level of prerequisite knowledge which is about symbol use in functions and algebraic expressions.

Taking into account the student related factors; the medium relationship in positive direction from socioeconomic status to comprehension cognitive level of prerequisite knowledge is determined. Moreover socioeconomic status has small relationships in positive direction to retrieval cognitive level of prerequisite knowledge and analysis cognitive level of prerequisite knowledge. Hence as students' socioeconomic status increase, their prerequisite knowledge also increase. This finding is supported with the literature (Adams & Holcomb, 1986;; Cooper & Robinson, 1991; Dew et al., 1984; Resnick et al., 1982; Suinn, Edie, Nicoletti, & Spinelli, 1972; Wigfield & Meece, 1988). Additionally students' self efficacy also has positive relationships towards retrieval cognitive level of prerequisite knowlege, comprehension cognitive level of prerequisite knowlege, and analysis cognitive level of prerequisite knowlege. While all these are small relationships, it can be concluded that the more self-efficacy students have, the more successful they are. Hence, students with high levels of positive self-efficacy perform academic tasks more successfully. This fact is in line with the ongoing literature (Mousoulides & Philippou, 2005; Pajares & Graham, 1999;

Pajares & Miller, 1994). However the relation of self-efficacy on academic performance may differ in different cultures. This fact can be an explanation for the small relations of self-efficacy. The fact that the relation of self-efficacy is small for Turkish students is also validated by the literature (Yıldırım, 2010).

Another important finding of the study is the relation of motivation on students' achievement of the prerequisite knowledge. While motivation has positive relation on comprehension cognitive level of prerequisite knowledge, it has negative relation on retrieval cognitive level of prerequisite knowledge. While retrieval cognitive level of prerequisite knowledge includes recalling and executing prerequisite knowledge, comprehension cognitive level of prerequisite knowledge is about integrating algebraic expressions and symbol use in functions. Students' motivation affects comprehension cognitive level of prerequisite knowledge in a positive direction but retrieval cognitive level of prerequisite knowledge in a negative direction. This finding can be explained with the fact that as students are more motivated mathematically, they have better command in comprehending prerequisite knowledge. The fact that students' motivation affects their success in a negative direction has been found by the studies in the literature recntly (Pekrun, Goetz, Titz & Perry, 2002). Additionally, the fact that these relations are small can be explained with the fact that mathematics motivation affecting students' less in the older years.

Another finding of the study is the small relation of test anxiety and social anxiety on the prerequisite knowledge in the negative direction. While there is a small negative relationship between social anxiety and comprehension cognitive level of prerequisite knowledge, there is a small negative relationship between test anxiety and analysis cognitive level of prerequisite knowledge. This finding is parallel to the research literature that anxiety negatively affects mathematics achievement (e.g. Cooper & Robinson, 1991; Dew et al., 1984; Hembree, 1990; Resnick, et al., 1982; Suinn, et al., 1972; Wigfield & Meece, 1988). There is evidence in the literature that, anxiety acts as an obstacle for the performance especially in the case of higher mental activities and conceptual process (Skemp, 1986). This fact explains the small relation of anxiety on the analysis and comprehension cognitive levels of prerequisite knowledge. Additionally in the model of the curent study, there has been found a nearly medium relationship from social anxiety to analysis cognitive level of prerequisite knowledge in positive direction. This fact indicates that as students' anxiety levels increase they may be more successful in analysis cognitive level of prerequisite knowledge. This fact is in line with the literature as there are studies in the literature demonstrating that students' achievement levels can be increased with their anxiety levels (Zakira & Nordin, 2007).

Furthermore, the present study assessed students' knowledge of derivative through different question types including open-ended questions which require carrying out procedures, giving meaningful explanations for the relationships between facts and principles, and correct application of procedures. In accordance with the findings of Pillay (2008) and Ferrini-Mundy & Lauten (1994) students might not focus on the solution in such a question format; instead they might focus on the symbolic representations or procedural solutions only. While solving open-ended questions the gap between students' symbolic understanding of algebraic manipulations and graphical realizations of the derivative concept (Ferrini-Mundy & Graham, 1994) might also take place. In line with this premise, one possible reason for the small relations may be the fact that students who participated to the study were used to encounter to multiple choice format of questions. Moreover, this compromises with the results of some studies (Booth, 1989, Becker, 1991; Breidenbach, et al., 1992) that suggests introducing students' robust tendencies of following the same procedures they had encountered, their manipulation of rules without reference to the meaning of the expressions, or their predominant reliance on the use of and the need for formulas.

The present study specified of prerequisite knowledge as independent from derivative knowledge and this specification was not disproved by the data. The premise is that students may not need to utilize from their prerequisite knowledge while performing on questions of derivative. When applying straightforward algorithms, they may not tend to justify their answers or make the links. This particular finding affirmed that derivative knowledge may not develop without or apart from prerequisite knowledge. In some circumstances, this result supported a traditional view that mathematical knowledge is a set of rules of propositions. However, the interactions in the model put forward the fact that including four types of cognitive domains is suitable for the derivative knowledge that it is affected by students' retrieval, comprehension, analysis, and knowledge utilization.

5.2 Conclusions

The factors included in the study are selected in accordance with the context of the measures used in order to assess students' prerequisite knowledge and cognitive levels through the use of confirmatory factor analysis. Accordingly, the cognitive factors in the present study are retrieval, comprehension, analysis, and knowledge utilization.

Although, no specific model of students' derivative achievement that involve the factors of the present study exist in the literature, the results are generally consistent with the findings of previous research studies. They provide general and partial support for the relations and interconnections among prerequisite and derivative knowledge through the cognitive processes. The single results of the study are summarized as follows:

In general in this study, students' affective variables and their socio economic status did not give strong relations with the cognitive variables. This might be partly due to the age of the students. Since sample includes university students, they could be considered as adults, and naturally, their parental socioeconomic caharactersitics are not effective as expected. The strong relation between soscioeconomic indicators and students achievement is generally reported for the younger students in the related literature. However, the affective variables as well as socioeconomic variable are not completely ineffective in the model tested. For the socioeconomic status variable, the path coefficients were all positive with the prerequisite latent variables, but the magnitudes of all the coefficients are at small and below small effect size levels. Similarly, all the other variables are positively related with the prerequisite latent variables except the anxiety and motivation latent variables.

Having a negative relation of anxiety latent varibale with comprehension and analysis prerequisite latent variables is an expected outcome. On the contrary, students who are highly motivated are successful in comprehension prerequisite latent varaible, but unexpectedly, this relation is negative with the retrieval prerequisite latent variable. As it was explained before, the retrieval dimension in the model tested includes items assessing students' memorized or recalled knowledgeas well as algorithmic executions in the prerequisite concepts of the derivative. Students who are motivated might have some interest in higher order tasks, such as symbolizing and matching skills as assessed in the comprehension prerequisite latent variable. It could be hypothesized that, students who developed these higher order skills, might fail on low level execution outcomes, which do not require any higher order performance. This finding gives an important message to the teachers who teach calculus. Motivated students should be directed to perform at least comprehension level tasks during the course rather than execution level excercises and problems. The course content should go beyond execution for the motivated students. As expected, test and social anxiety have negative relations with higher order prerequisite skills. This finding is frequently reported in the literature. Once students get anxious about mathematics exams related tasks, they are likely to fail in prerequisite skills. Especillay the one which requires integrating, symbolizing, matching, classifying, specifying, and generalizing skills.

Surprizingly, positive relation was observed between social anxiety and analysis prerequisite skills. This seems rather hard to interpret, but this particular latent variable reflects anxiety in mathematics with reference to the peer group interactions. It is not test anxiety per se. Thus, this kind of anxiety might be required for a better understanding of concepts related to matching, classifying, analyzing errors, generalizing, and specifying. What should be avoided here is the test anxiety of the Turkish university students.

For the the rest of the relations, following conclusions could be written:

1. For higher achivement in derivative, different groups of skills should be considered.
2. All the groups have different relations with the achievement in derivative with different magnitudes.
3. Almost all of the cognitive levels are important to achieve learning in derivative, including the retrieval outcomes.
4. In terms of prerequisite skills, the most important variable is the knowledge utilization. This means, in terms of prerequisite skills and subject matters, for achieving success in the derivative concept, students should be able to achieve knowledge utilization in prerequisite skills. This basically covers decision making and problem solving.
5. In general, both analysis and knowledge utilization are the two domains which are definitely required for the learning achievement of derivative concepts.
6. Teachers and instructors should consider the cognitive skills of the students into account during teaching. In general, teachers and instructors in Turkey emphasis on the subject matter, not the cognitive skills. This might give a greater emphasis on

the execution tasks, which was taken under the retrieval latent variable in the persent study. However, when other dimensions are considered, such as analysis and knowledge utilization; it was found that their impacts are more than retrieval tasks. Execution dominated calculus education will not enhance students' comprehension of the basics of the derivative concepts, as evidenced by no significat relation between retrieval prerequisite latent variable and comprehension latent variable.

7. Among all the prerequisite cognitive groups, analysis has significant relation with all of the derivative latent variables. This finding clearly points out the importance of piecewise functions, dependent and independent variables, indeterminate forms of limits, and the rate of change subject matters; and retrieval, comprehension, analysis, and knowledge utilization cognitive tasks.
8. For a successful teaching of derivative, the prerequisite knowledge and skills, and four groups of cognitive tasks should be considered in the course plannings.

5.3 Implications

In the light of the results and conclusions of the study as well as the relevant literature the following educational suggestions could be recommended:

Comprehension cognitive level of derivative has the largest effect size for the tested model. It can be concluded that students' need to use diverse cognitive levels of derivative more affectively. Besides, the teaching of the derivative concept should necessarily take into account the cognitive levels with the prerequisite knowledge. The utilization of knowledge in derivative is the desired cognitive stage. This cognitive level includes drawing the graph of a function, the interpretation of instantaneous rate of change, and solving problems with the derivative (e.g. minimum/maximum problems and optimization problems). Students' all four of the cognitive levels of prerequisite knowledge should be supported for utilizing knowledge in the derivative. This means that students' should be equipped with the executing prerequisite knowledge, using symbols, analysing and generalizing the prerequisite knowledge and finally utilize prerequisite knowledge in algebra, functions, limits, and tangency concepts in order to generate new conclusions. Moreover, they should be taught the four of the prerequisite concepts so that they can apply their knowledge in specific situations.

Prerequisite knowledge for derivative should be endorsed in calculus courses considering developing students' cognitive levels. Particularly, in the current educational system, students are not very familiar with knowledge utilization along their education. Therefore when they face with authentic items their performance is only restricted to what they have encountered so far. Hence, situations that require the improvement of mathematical thinking could be encouraged by the calculus instructors. The knowledge utilization cognitive domain of prerequisite knowledge has a large relationship towards comprehension cognitive domain of derivative. Hence for a good command in the derivative, students need to achieve the knowledge utilization cognitive domain of prerequisite concepts. Hence the calculus instructors should conduct their teaching with this information.

As consistent with the literature, though in this study students' retrieval skills has a moderate effect, it is believed to be among strong predictors of derivative achievement. Therefore, instructors should be aware of this situation and be able to find ways to improve the interrelations between the retrieval cognitive levels and other cognitive levels.

Calculus instruction and the previous formal instruction in the application of derivative tend to hinder students' various cognitive skills. It furthermore limits their utilization of knowledge and analyzing cognitive levels, while causing those difficulties in the long run. If students are able to internalize derivatives, the calculus curriculum can be designed in such a way that students recognize various derivative situations; that students have a clear understanding of the interrelationship among prerequisite knowledge and derivative. Instruction should also move students through meaningful reasoning for using various cognitive skills in the development of derivative teaching. Most instruction passes directly from the characterization of definitions to the memorization of facts and routine application of procedures and carrying out procedures without utilization of knowledge. Overwhelmingly, many students tend to conceive derivative as a rigid subject based on rules, principles, and routine application of algorithms without the awareness of interrelationships among the multiple representations of the concept. There is a need to structure learning environments that reinforce the idea that derivative does not only include arbitrary rules but rather connections among these rules. Therefore, teachers, administrators and instructional designers should make clear establishments about how derivative instruction can be sequenced to enhance the effective development of concepts, relations and procedures.

Competence in derivative requires all four types of cognitive levels with the prerequisite knowledge. Developing students' cognitive skills is an important avenue for improving their knowledge of derivative. This study hopes to inspire calculus instructors to undertake fundamental instructional reform that emphasizes the relative efficiency and effectiveness of the relations between cognitive levels in derivative and its prerequisite knowledge. Mathematics education researchers can support this instructional function by documenting different topics contextualized in four different types of cognitive levels and investigating how such contexts affect students' performance. The careful analysis of the hierarchical and nested relations among knowledge types and use of this analysis to inform instruction can provide different perspectives for teaching and learning of derivatives.

In addition, taking into consideration the student related factors, students' self-efficacy towards the derivative can be supported for their derivative achievement. While mathematics motivation has small effects on derivative achievement, it affects the retrieval cognitive domain of prerequisite knowledge in negative direction. On the other hand motivation affects the comprehension cognitive level in positive direction. From this finding it can be determined that students' motivation should be supported together with giving them options to use various level cognitive skills. It is observed that although some students have high motivational attitudes they seem to be unaware of their real ability of derivative. Motivation usually effects mathematics achievement in a positive way. Other contradictory results may be the indicators of students' capability of their mathematics achievement.

5.4 Limitations

Conducting self-report questionnaires yields to depend on the honesty of the participants. This fact can lead to response bias and existence of unreliable results to some extent. The instruments were administered on a single occasion for the purpose of locating same students rather than conducting them on separate occasions. However, as more time is required to complete the test, this administration may lead students to pay less attention when responding the questionnaires. Moreover, it guaranties to obtain same students' responses for both the questionnaires and the derivative achievement test.

Every possible attempt is made to make sure that students do not regard the test as a test for measuring their derivative achievement or proficiency. However, it is still possible for some students to perceive it in such a way and this could have some effect on their answers.

The derivative test was designed by the researcher and based on the table of specifications. The cognitive levels are taken into account with the prerequisite test and the derivative test. However, each cognitive level is assessed with limited number of questions in DAT as seen in Appendix E. This constitutes as a limitation of the present study. Moreover, some participants may not be familiar with all of the question types although every effort was made to ensure that answers to the questions do not require specific knowledge. As a result, this fact could provoke skipping the questions and guessing, hence to some extent misleading an inaccurate measurement.

Despite these mentioned limitations, most of the hypothesized relationships were statistically significant and substantial in size. This fact supports the robustness of the structural model related to prerequisite and derivative knowledge. There are some strengths of the results of the present study, like using the structural equation modeling and specificating direct and indirect effects of the factors. These kind of advanced statistical techniques that employ structural models reflect the complexity of the relationships among various constructs by hypothesizing the direct effects and are more robust.

5.5 Recommendations for Future Research

1) One of the most striking results was the effect of comprehension cognitive level on students' derivative conceptions. This fact may need in depth attention and investigation particularly for the students who study calculus.

2) Only one model was tested in the current study, various models with different contributing factors can be tested and evaluated with respect other attributes.

3) The instruments used in this study can be developed to obtain more reliable results. The outcomes can be supported and strengthened with qualitative studies.

4) It is evident that future research must continue to examine the relationships among components of derivatives and cognitive levels measures. Further research may explore the utilization of cognitive levels and regulation with the scores on other calculus areas such as integration.

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APPENDIX A

THE SURVEY TEST

Bu ankette, sizinle ilgili sorular vardır. Kimi sorularda belli durumlar, kimi sorularda ise sizin fikriniz sorulmaktadır.
Her soruyu dikkatlice okuyup olabildiğince kesin cevaplayınız.
Her sorunun ardında işaretlemeniz için cevaplar vardır. Tercihinizi (X) ile işaretleyiniz.
Soruları dikkatlice okuyup, en doğru olan şıkkı işaretleyiniz. Eğer cevabınızı değiştirmeye karar verdiyseniz, işaretlediğiniz şıkkı karalayıp diğer şıkkı işaretleyebilirsiniz. Herhangi bir soruyu anlamadığınızda ya da nasıl cevaplayacağınıza karar veremediğinizde yardım isteyebilirsiniz.

Teşekkürler
Arş. Grv. Fulya Kula
ODTU - Eğitim Fakültesi
Tlf: 0 312 210 36 86

1. Doğduğunuz : Yıl ___ Ay ___ Gün ___

2. Cinsiyetiniz : K ___ E ___

3. Üniversite : ________________________________

Bölüm : ________________________________

4. Yıl ________________________________

5. Üniversite not ortalamanız : _______________/_________________
(İçinde bulunulan döneme kadarki)

6. Evinizde bulunan kitap sayısı nedir? (dergi, gazete ya da okul kitapları hariç)

- Hiç ya da çok az (0-10 kitap) ☐
- Bir rafı dolduracak kadar (11-25 kitap) ☐
- Bir kitaplığı dolduracak kadar (26-100 kitap) ☐
- İki kitaplığı dolduracak kadar (101-200 kitap) ☐
- Üçden fazla kitaplığı dolduracak kadar (200'den fazla kitap) ☐

Evinizde aşağıdakilerden hangisi / hangileri var?

7. Bilgisayar (Bilgisayar oyunları veya televizyon oyunları hariç) ☐

8. İnternet bağlantısı

9. Kendinize ait bilgisayar

10 Ailenizin aylık geliri : ____________________________ (TL)

11 Annenizin tamamladığı en yüksek eğitim seviyesi nedir?

İlkokul
Ortaokul (ilkokul II. Kademe)
Lise (ortaöğretim)
Üniversite (önlisans)
Üniversite (lisans)
Yüksek lisans (master)
Doktora

12 Babanızın tamamladığı en yüksek eğitim seviyesi nedir?

İlkokul
Ortaokul (ilkokul II. Kademe)
Lise (ortaöğretim)
Üniversite (önlisans)
Üniversite (lisans)
Yüksek lisans (master)
Doktora

	Aşağıda verilen ifadelere ne derecede katılıyorsunuz?	Kesinlikle	Katılmıyorum	Kararsızım	Katılıyorum	Kesinlikle
13	Bu bölümde olmamın sebebi, ilgilendiğim konularda daha fazla bilgi sahibi olmaktır.					
14	Akademik konuları çalışmanın çoğu kez gerçekten heyecan verici olduğunu düşünüyorum.					
15	Derslerde tartışılan ilginç konular hakkında daha çok şey öğrenmek isterim.					
16	Akademik konularla ilgili ders bittikten sonra da araştırma yapmayı sürdürürüm.					
17	Aldığım derslerin ileride bana iyi bir iş imkanı sağlayacağını düşünüyorum.					
18	Bu bölümde olmamın sebebi daha iyi bir iş bulmama yardımcı olacağıdır.					
19	Derslere, ileride meslek yaşantıma destek sağlayacakları için katlanıyorum.					
20	Aldığım derslerden çok, alacağım derecelerle ilgileniyorum.					
21	Rekabeti severim; beni harekete geçirir.					
22	Buradaki derslerimle gerçekten başarılı olmam benim için					

	önemlidir.					
23	Arkadaşlarımdan daha başarılı olmak benim için önemlidir.					
	Aşağıdaki ifadeler sizi ne derecede kaygılandırıyor?	Kesinlikle	Kaygılanmam	Kararsızım	Kaygılanırım	Kesinlikle
24	Bir matematik dersinin dönem sonu sınavına girmek					
25	Bir hafta öncesinden bir matematik sınavını düşündüğümde					
26	Bir gün öncesinden bir matematik sınavını düşündüğümde					
27	Bir saat öncesinden bir matematik sınavını düşündüğümde					
28	Beş dakika öncesinden bir matematik sınavını düşündüğümde					
29	İyi geçtiğini düşündüğüm bir matematik sınavının sonucunun ilan edilmesini beklerken					
30	Transkriptimde yılsonu matematik notumu gördüğümde					
31	Mezun olabilmek için belli sayıda matematik dersini tamamlamak zorunda olduğumu fark ettiğimde					
32	Matematik dersinde daha önceden haber verilmemiş quiz tipi bir sınava girdiğimde					
33	Matematik sınavına çalışırken					
34	Ö.S.S. gibi bir standart testin matematik bölümünü cevaplandırırken					
35	Bir matematik dersinin ara sınavına girmekten					
36	Ödevimi yapmak için matematik kitabımı elime aldığımda					
37	Bir sonraki derse getirilmek üzere, içerisinde birçok zor matematik problemi bulunan bir ev ödevi verildiğinde					
38	Bir matematik sınavı için çalışmaya hazırlanırken					
39	Beş basamaklı bir sayıyı iki basamaklı bir sayıya bölme işlemini, kağıt-kalemle, tek başıma yaparken					
40	Kağıt üzerinde 976+777 toplamasını yaparken					
41	Alışverişten sonra kasa fişini okurken					
42	1 Türk Lirası'ndan daha pahalı bir malın KDV'sini hesaplarken					
43	Aylık gelir ve giderlerimi hesaplarken					
44	Benden kağıt üzerinde bir dizi toplama işlemi yapmam istendiğinde					
45	Alt alta bir dizi sayıyı toplarken birinin beni izlemesinden					
46	Bir yemek sonrasında, fazla ödeme yaptığımı düşündüğümde, hesabı yeniden toplarken					
47	Bir dernekte aidatları toplayarak, toplanan miktarı takip etmekten sorumlu kişi olmaktan					
48	Ehliyet sınavına çalışırken, gerekli rakamları ezberlerken (Örneğin: Farklı hızlarda giden araçların durmaları için gerekli minimum mesafeler gibi.)					
49	Üyesi olduğum derneğe gelen aidatların ve dernek harcamalarının hesabını yapmaktan					
50	Hesap makinesi ile işlem yapan birini izlerken					
51	Benden kağıt üzerinde bir dizi bölme işlemi yapmam istendiğinde					
52	Benden kağıt üzerinde bir dizi çıkarma işlemi yapmam istendiğinde					

53	Benden kağıt üzerinde bir dizi çarpma işlemi yapmam istendiğinde					
	Kendinizi türev konusunda asagidaki beceriler boyutunda ne derece yeterli buluyorsunuz?	Çok	Yeterliyim	Kararsızım	Yeterli	Hiç Yeterli
54	Türevin tanımını bilmek					
55	Türevi sembolik olarak ifade etmek					
56	Çeşitli fonksiyonların türevini almak					
57	Türev kullanarak grafik çizmek					
58	Türev kullanarak minimum/maksimum problemlerini çözmek					
59	Türevi geometrik olarak yorumlamak					
60	Günlük hayatta türev örnekleri bulmak					
61	Türevle ilgili teoremleri anlamak					

APPENDIX B

CHECKLIST FOR VALIDITY OF DPQ AND DSS

Definition: This test was designed to get information about university students' demographic profiles (DRQ) and measure their self-efficacy in the derivative concept (DSS). Please put a check sign(✓) and provide suggestions if any for the statements of the test.

Self-Efficacy Scales: The self-efficacy scales should be task (or even item) specific according to the literature (Pajares & Miller, 1994). The context of task specificity of DSS requires the items to be directly related to the objectives of the subject-matter. A self-efficacy statement is exact like: "Can you solve this specific problem?" (Pajares & Miller, 1994). Being in line with the suggestions of the literature, the DSS has 8 items of the general objectives of the derivative concept. The objectives of derivative are:

- Knowing the definition of derivative
- Express derivative symbolically
- Take derivative of various functions
- Draving graphs using the derivative knowledge
- Solving minimum/maximum problems using derivative knowledge
- Interpreting derivative geometrically
- Finding daily life examples for derivative
- Understanding theorems about derivative

The Survey Test																													
Demographic Profiles Questionnaire																													
10		9			8			7			6			5			4			3			2			1			Item Number
NO	YES	Sg.*	NO	YES	Sg.*	NO	YES	Sg.*	NO	YES	Sg.*	NO	YES	Sg.*	NO	YES	Sg.*	NO	YES	Sg.*	NO	YES	Sg.*	NO	YES	Sg.*	NO	YES	
																													Aims and format of the items are clear
																													Content is suitable for university students
																													The content is comprehensive
																													Sample of items are adequate
																													Items match with the objectives
																													The layout is clear and is legible
																													Format of the items are appropriate
																													There is no ambiguity in the options
																													Space is allocated for answers
																													Language is appropriate and free of grammar and spelling errors
																													Items are easy to read
																													Instructions are clear

			Sg.*												
		11	YES												
			NO												
			Sg.*												
		12	YES												
			NO												
			Sg.*												
	Derivative Self-Efficacy Scale	54	YES												
			NO												
			Sg.*												
		55	YES												
			NO												
			Sg.*												
		56	YES												
			NO												
			Sg.*												
		57	YES												
			NO												
			Sg.*												
		58	YES												
			NO												
			Sg.*												
		59	YES												
			NO												
			Sg.*												
		60	YES												
			NO												
			Sg.*												
		61	YES												
			NO												
			Sg.*												

*Sg. : If you have any suggestions please indicate in the free space

APPENDIX C

TEST PLAN FOR THE DAT

TEST PLAN FOR THE DERIVATIVE ACHIEVEMENT TEST

The Derivative Achievement Test (DAT) is designed to to measure university students' achievement in the derivative concept and also their achievement in this concept's prerequisite concepts. The prerequisite concepts of the derivative are determined in four main topics which are algebra, functions, limits, and tangency. Besides DAT has a cognitive dimension for both derivative and the prerequisite concepts. The cognitive skills of DAT are retrieval, comprehension, analysis, and knowledge utilization. The plan identifies the cognitive and knowledge dimensions of DAT, objectives, and the table of specifications of DAT.

1.1 Cognitive Dimension of DAT

In the following specifications four cognitive domain types from Marzano's Taxonomy of Educational Objectives are used; *retrieval*, *comprehension, analysis*, and *problem solving*. The cognitive system within the taxonomy is examined in four levels;

1. Retrieval
2. Comprehension
3. Analysis
4. Knowledge Utilization

<u>The processes of each cognitive level is as follows:</u>

Level 1: **Retrieval**: recognizing, recalling, and executing

Level 2: **Comprehension**: integrating, symbolizing

Level 3: **Analysis**: matching, classifying, analyzing errors, generalizing, specifying

Level 4: **Knowledge utilization**: decision making, problem solving, experimenting, investigating (experimenting and investigating are excluded from the current study)

This can be summarized in Table 1 as follows:

Table 1

Retrieval	Recognizing Recalling Executing
Comprehension	Integrating Symbolizing
Analysis	Matching Classifying Analyzing errors Generalizing Specifying
Knowledge utilization	Decision making Problem solving Experimenting (NI*) Investigating (NI*)

*: NI (these sub-domains were not included in this study)

The following section describes each cognitive domain of the studyin terms of Marzano's taxonomy (the cognitive domains and the sub-domains), the relation of which can be seen in Table 1.

The Four Cognitive Domains of the Study in Brief:

1. **Retrieval:**

At this level there is no expectation from the student to demonstrate the knowledge in depth. Neither the student is expected to understand the basic structure of the knowledge or its critical versus noncritical elements. This domain can be divided into three sub-domains in Marzano's taxonomy: recognizing, recalling, or executing knowledge.

Recognizing: determining whether the given information is accurate, inaccurate, or unknown is considered in this sub-domain. In the case of recognizing objectives and tasks, terms and phrases like the following might be used:

- Select from a list
- Identify from a list
- Determine if the following statements are true

Recalling: this sub-domain involves producing accurate information as opposed to simply recognizing it. Generally, the format for *recalling* tasks is short written or oral constructed-response formats. On occasion, fill-in-the-blank formats are used.

Some objectives and tasks like the following might be used:

- Recall
- Exemplify
- Name
- List
- Label
- State
- Describe
- Who
- What
- Where
- When

Executing: this sub-domain involves actually carrying out a mental or physical procedure as opposed to simply retrieving or recalling information about such procedures. However, this sub-domain does not relate to complex mental and psychomotor procedures. In *executing sub-domain* the students are not expected to show complex mental procedures.

Some objectives and tasks like the following might be used:

- Add
- Subtract
- Multiply
- Divide
- Apply
- Demonstrate
- Draft
- Complete
- Locate
- Make
- Solve
- Read
- Use
- Write

2. Comprehension

Comprehension involves both the process of integrating and symbolizing knowledge and examining knowledge with the intent of generating new conclusions. In comprehension cognitive domain, students are expected to identify the critical or essential information as opposed to noncritical or nonessential information. *Comprehension* domain can be investigated in two sub-domains: *integrating* and *symbolizin.*

Integrating: this sub-domain involves identifying and articulating the critical or essential elements of knowledge. The most common format for integrating tasks is an extended written or oral constructed response.

While the verb *integrate* is rarely if ever used, some objectives and tasks like the following might be used:

- Describe how or why
- Describe the key parts
- Describe the effects
- Describe the relationship between
- Explain ways in which
- Make connections between
- Paraphrase
- Summarize

Symbolizing: this sub-domain involves depicting the critical aspects of knowledge in some type of nonlinguistic or abstract form. The process of symbolizing is rarely explicit in benchmark statements. The obvious format for symbolizing tasks is a representation that does not rely on language. However this does not mean that language is incompatible with symbolizing tasks.

The term *symbolize* is frequently used in symbolizing objectives and tasks while other terms and phrases may include:

- Depict
- Represent
- Illustrate
- Draw
- Show
- Use models
- Diagram
- Chart

3. Analysis

The analysis process involve examining knowledge with the intent of generating new conclusions. Analysis have five sub-domaind; matching, classifying, analyzing errors, generalizing, and specifying.

Matching: this sub-domain involves identifying similarities and differences. It is important to note that matching can involve more than two examples of a specific type of knowledge. While the verb *match* is rarely used in matching tasks, the most common used ones are *compare* or *compare and contrast*. The following terms and phrases might also be used:

- Categorize
- Differentiate
- Discriminate
- Distinguish
- Sort
- Create an analogy
- Create a metaphor

Classifying: this sub-domain goes beyond organizing items into groups or categories. Rather, classifying involves identifying the superordinate category in which knowledge belongs as well as the superordinate categories (if any) for knowledge. The most common format for classifying tasks is short or extended written and oral constructed-response formats.

The term *classify* is frequently used in classifying tasks as well as the following terms and phrases:

- Organize
- Sort
- Identify a broader category
- Identify categories
- Identify different types

Anaylzing errors: this sub-domain involves identifying factual or logical errors in knowledge or processing errors in the execution of knowledge. The common format for analyzing errors is short and extended written or oral constructed-response formats. Additionally, more structured formats might be employed.

The verb *analyze errors* can be used and other terms and phrases for this sub-domaininclude the following:

- Identify problems
- Identify issues
- Identify misunderstandings
- Assess
- Critique
- Diagnose
- Evaluate
- Edit
- Revise

Generalizing: this sub-domain involves inferring new generalizations and principles from information that is known or stated. The most common format for generalizing tasks is short or extended written or oral constructed-response formats. These tasks might be relatively ınstructured.

The term *generalize* can be used in generalizing tasks along with terms and phrases like the following:

- What conclusions can be drawn
- What inferences can be made
- Create a generalization
- Create a principle
- Create a rule
- Trace the development of
- Form conclusions

Specifying: this sub-domain involves making and defending predictions about what might happen or what will necessarily happen in a given situation. The tasks for specifying are generally short and extended wirtten or oral constructed-response formats.

Specifying objectives and tasks can use the term *specify* along with the following terms and phrases:

- Make and defend
- Predict
- Judge
- Deduce
- What would have happen
- Develop an argument for
- Under what conditions

4. Knowledge Utilization

While the knowledge utilization level in Marzano's taxonomy includes four processes (decision making, problem solving, experimenting, and investigating), only the decision making and problem solving processes are under the area of interest of the current study. of the cognitive domain

Decision making**:** this sub-domain involves selecting among alternatives that initially appear equal. The most common format for decision-making tasks is short or extended written or oral constructed-response formats.some decision-making tasks may be quite structures as well.

The term *decide* is commonly used in decision-making objectives and tasks along with other terms and phrases including the following:

- Select the best among the following alternatives
- Which among the following would be the best
- What is the best way
- Which of these is most suitable

***Problem solving*:** this sub-domain involves accomplishing a goal for which obstacles or limiting conditions exist. Problem solving process is closely related to decision making in that latter is frequently a subcomponent of problem solving. However, whereas decision making does not involve obstacles to a goal, problem solving does. The most common format for problem-solving tasks is short or extended written and constructed-response formats.

The term *solve* is frequently used in problem-solving tasks and objectives along with terms and phrases like the following:

- How would you overcome
- Adapt
- Develop a strategy to
- Figure out a way to
- How will you reach your goal under these conditions

Charles et al. (1987) suggested seven problem-solving thinking processes in constructing items to assess student performance.

1. Understand/formulate the question in the problem.
2. Understand the conditions and variables in the problem.
3. Select/find data needed to solve the problem.
4. Formulate sub problems and select an appropriate solution strategy to pursue.
5. Correctly implement the solution strategy and attain the sub goals.
6. Give an answer in terms of the data in the problem.
7. Evaluate the reasonableness of the answer.

In this study, the cognitive domain of *problem solving* will be taken into consideration in line with both Marzano’s taxonomy and the seven processes seen above.

1.2 Prerequisite Concepts of DAT

The prerequisite concepts students must have for achievement in derivative are algebra, functions, limits, and tangency. The use of each concept in the derivative concept are explained in the following table.

Algebra	• derivative taking process • applying distributive law to expand the brackets • simplifying algebraic fractions • solving simple inequalities • ratio and proportion ideas

	• rate of change • average rate of change • instantaneous rate of change • operation on the symbols of the derivative
Functions	• co-varying nature of the functions • derivative of a function as a separate function • the algebraic representation of the derivative function • derivative as an operation on functions • piecewise functions • use of algebraic formulas with the function concept • algebraic representations of functions • variables
Limits	• limit of the difference quotient • formal definition of the limit concept • limit definition of derivative • limit of secant lines as the tangent line
Tangency	• geometric representation of derivative • drawing the graph of a function via derivatives • tangent line • limit of secant lines as the tangent line

1.3. Objectives of DAT

The objectives of the DAT are as follows:

1. Objective: Represents the simplifications with fractional algebraic expressions
2. Objective: Creates mathematical equations from different geometric/mathematical equations
3. Objective: Recognizes the definition for the symbol of rate of change ($\frac{\Delta y}{\Delta x}$)
4. Objective: Computes the degree of polynomials and functions
5. Objective: Recalls the definition for the infinitesimal concept
6. Objective: Makes operations on algebraic expressions
7. Objective: Discriminates the dependent and independent variables in a given situation
8. Objective: Solves problems about the limits of series
9. Objective: Concludes that there are infinitely many secant lines on the two points of a circle
10. Objective: Form conclusions for the graphs of functions with the related real-life expressions
11. Objective: Computes the intersection point of a function with the y-axis, in the form of ordered pairs
12. Objective: Selects the data needed to solve the problem about piecewise functions
13. Objective: Gives the answer of the problem about the average rate of change using the given data
14. Objective: Selects the data needed for the solution of the problem about the tangency
15. Objective: Interprets the meaning or rate of change in real life problems
16. Objective: Identifies the limits with indeterminate forms and calculates this limit

17. Objective: Determines if the given expressions denotes a function
18. Objective: Selects the data needed to solve the minimum/maximum problems
19. Objective: Determines different statements of the limit definition of derivative as showing the same symbol (Namely the two limit definitions of derivative: $\lim_{h\to 0}\frac{f(x+h)-f(x)}{h}$ and $\lim_{x\to x_0}\frac{f(x)-f(x_0)}{x-x_0}$)
20. Objective: Identifies the functions which has the derivative in the given interval from a given list
21. Objective: Computes the derivative of a polynomic function
22. Objective: Concludes that the limit of secant lines is the tangent line
23. Objective: Utilizes his/her knowledge of the graph of the derivative function (f'), to make inferences about the function itself (f)
24. Objective: Criticizes the meaning of the chain rule in derivatives; $\frac{dy}{dx}=\frac{dy}{du}\frac{du}{dx}$

    Objective: Determines the derivative as a separate function

    Objective: Concludes that $\frac{dy}{dx}$ is also the ratio of two infinitesimals

    Objective: Recalls the limit definition of derivative; namely $\lim_{x\to a}\frac{f(x)-f(a)}{x-a}$

    Objective: Specifies the limit definition of derivative ($\lim_{h\to 0}\frac{f(x+h)-f(x)}{h}$) with some algebraic operations on the limit.
25. Objective: Computes the maximum point of a function given with the graphical representation, in the form of ordered pairs
26. Objective: Gives the answer of the problem about the instantaneous rate of change using the given data
27. Objective: Recalls the meaning of the term $\frac{dy}{dx}$
28. Objective: Gives the answer of the problem about the derivatives (speed) using the given data
29. Objective: Interprets the meaning of instantaneous rate of change in real life problems

1.4. Table of Specifications

	Retrieval	Comprehension	Analysis	Knowledge Utilization
Prerequisite Knowledge	1, 4, 6, 11	3, 5, 15, 17	7, 10, 12, 13	2, 8, 9, 14
Derivative Knowledge	21, 25, 28	19, 20, 27, 29	16, 24, 26	18, 22, 23

APPENDIX D

THE CHECKLIST FOR FACE AND CONTENT RELATED VALIDITY OF DAT

Definition: This test was designed to get information about university students' achievement in derivative and its prerequisite concepts in line with the cognitive skills (Please see the Test Plan provided to you, for more detail about the prerequisite concepts and the cognitive skills mentioned). Please put a check sign(√) and provide suggestions if any for the statements of the test.

	Item Number		Aims and format of the items are clear	Content is suitable for university students	The content is comprehensive	Sample of items are adequate	Items match with the objectives	The layout is clear and is legible	Format of the items are appropriate	There is no ambiguity in the options	There are no plausible distracters	There is no ambiguity in the options	Space is allocated for answers	Language is appropriate and free of grammar and spelling errors	Items are easy to read	Instructions are clear	Items do not encourage guessing
DAT	1	YES															
		NO															
		Sg.*															
	2	YES															
		NO															
		Sg.*															
	3	YES															
		NO															
		Sg.*															
	4	YES															
		NO															
		Sg.*															

	5	YES															
		NO															
		Sg.*															
	6	YES															
		NO															
		Sg.*															
	7	YES															
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		Sg.*															
	8	YES															
		NO															
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	9	YES															
		NO															
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	10	YES															
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	22	YES															
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		Sg.*															
	23	YES															
		NO															
		Sg.*															
	24	YES															
		NO															
		Sg.*															
	25	YES															
		NO															
		Sg.*															
	26	YES															
		NO															
		Sg.*															
	27	YES															
		NO															
		Sg.*															
	28	YES															
		NO															
		Sg.*															
	29	YES															
		NO															
		Sg.*															

*Sg. : If you have any suggestions please indicate in the free space

Please fill the following table of specifications, by placing each item in DAT to the corresponding cell. Please see the Test Plan provided to you, for more detail about the prerequisite concepts and the cognitive skills mentioned.

	Retrieval	**Comprehension**	**Analysis**	**Knowledge Utilization**
Prerequisite				
Derivative				

APPENDIX E

DERIVATIVE ACHIEVEMENT TEST

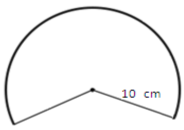
PART I
PREREQUISITE TEST

1) **Aşağıdaki soruda boşluğu uygun ifade ile doldurunuz.**

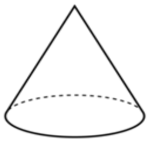
$a, b, c, d \epsilon \mathbb{R} - \{0\}$ olmak üzere, $x = ab$, $y = bc$ ve $z = abcd$ ise

$\frac{xy}{z}$ ifadesi en sade biçimde ___________ şeklinde yazılır.

2) Yarıçapı10 cm olan Şekil 1'deki gibi bir daire parçası bükülerek Şekil 2'deki gibi bir koni oluşturuluyor.



Şekil 1


Şekil 2

Buna göre koninin hacmini tek değişkenli olarak belirtiniz.

____

____

3) $\frac{\Delta y}{\Delta x}$ **aşağıdakilerden hangisini ifade etmektedir?**

A) İki değişim miktarının oranı
B) Bir noktadaki değişim oranı
C) Bir noktadaki eğim
D) Bir noktadaki limit
E) Basit kesir

4) $4x^2 + 5x^3 + 2x + 1$ **polinomunun derecesi kaçtır?**
A) 1 B) 2 C) 3 D) 4 E) 5

5) **Sonsuz küçük (infinitesimals) kavramını aşağıdakilerden hangisi en iyi tanımlamaktadır?**

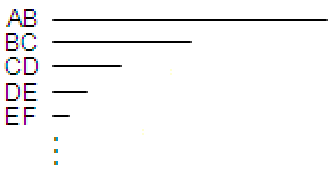
A) $1/\infty$ oranına eşit olan sayılar
B) Limiti sıfıra eşit olan sayılar
C) Ölçülemeyecek küçüklükteki sayılar

D) Gerçek hayatta karşılaşılmayan sayılar
E) Limiti eksi sonsuza $(-\infty)$ eşit olan sayılar
6) $[3(x+k)^2+2]-(3x^2+2)$ **ifadesini en sade biçimde yazınız.**

7) Sigara içmenin ve aşırı stresin kanser olmayı etkilediğini düşünen bir araştırmacı, bu durumla ilgili bir araştırma yapmak istiyor. **Bu araştırma için kullanılacak bağımlı ve bağımsız değişkenler, sırasıyla hangi seçenekte doğru olarak verilmiştir?**

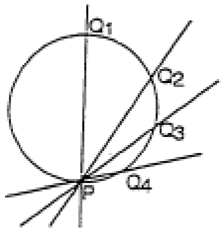
A) Stres, Kanser
B) Stres, Sigara
C) Kanser, Sigara
D) Sigara, Stres
E) Sigara, Kanser

8) Uzunluğu 1 *birim* olan AB doğru parçasına, uzunluğu $\frac{1}{2}$ *birim* olan bir BC doğru parçası ekleniyor. Aynı yöntemle bu parçalara uzunlukları sırasıyla $\frac{1}{4}, \frac{1}{8}, \frac{1}{16}$, ... *birim* olan şekildeki gibi CD, DE, EF,… doğru parçaları ekleniyor. **Doğru parçalarının uzunluğu sıfıra yaklaştıkça AB+BC+CD+DE+EF+... parçalarının toplamı için aşağıdakilerden hangisi söylenebilir?**



A) ∞
B) 2
C) 2’ye yakınsar
D) 2’den küçük bir sayı
E) 2’den büyük bir sayı

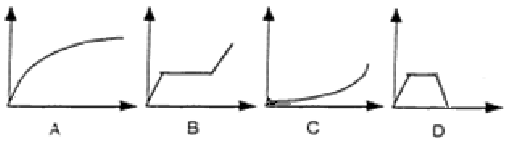
9) Aşağıdaki şekilde bir çember ve üzerindeki sabit bir P noktası gösteriliyor. PQ doğruları, çember üzerindeki P noktasından Q noktalarına şekildeki gibi çiziliyor ve her iki yönde doğru uzuyor. Bu şekildeki doğrular, ***sekant doğruları*** (***secant lines***) olarak adlandırılmaktadır.



Şekilde görülen doğrular dışında kaç farklı sekant doğrusu çizilebilir?

A) 0 B) 1 C) 2 D) 4 E) ∞

10) Aşağıda verilen grafiklerde; x-ekseni zamanı, y-ekseni ise evden uzaklığı belirtmektedir.

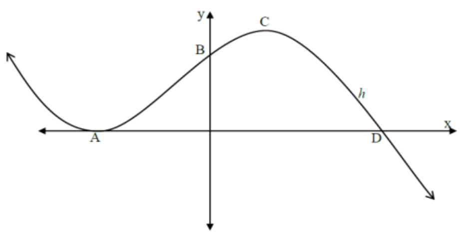


Aşağıdaki durumlar için hangi grafiğin en iyi ifade ettiğini belirleyiniz.

İfade	**Durum**
Evden ayrılmıştım ki kitaplarımı unuttuğumu fark ettim ve kitaplarımı almak için geri döndüm	
Son durakta otobüsten indim ve yola yürüyerek devam ettim	
Arabanın lastiği patlayıncaya kadar bir sorun yoktu	
Sakin bir şekilde yola başladım fakat geç kalacağımı anladığımda hızlandım	

11) Aşağıda bir f fonksiyonunun grafiği verilmiştir.

$$f(x) = -x^3 + 3x + 2 = (x+1)^2(2-x)$$



Buna göre <u>B noktasının koordinatları</u>nı belirleyiniz.

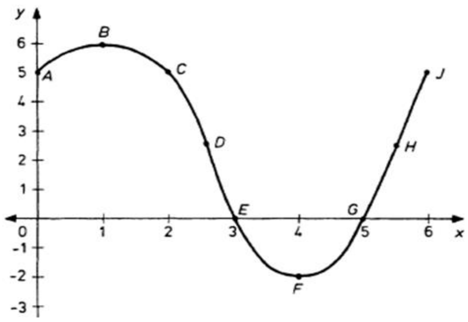
12) $f(x) = \begin{cases} 3x^2, x \square 1 \\ 4x, \ x \square 1 \end{cases}$ fonksiyonu veriliyor.

$f(1)$ değerini bulmak için $\square$ yerine yazılabilecek işaretler sırasıyla hangisi olabilir?

I. $>,<$
II. $\geq,<$
III. $=,<$

A) I B) II C) III D) II ve III E) I, II ve III

13) Aşağıda $x \in [0,6]$ aralığında bir fonksiyonun grafiği görülmektedir



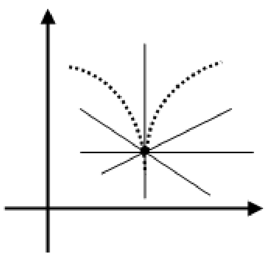
Belli noktalarda, y'nin x'e gore ortalama değişim hızı (average rate of change) aşağıdaki gibidir:

I. A'dan B'ye ortalama değişim hızı
II. B'den E'ye ortalama değişim hızı
III. A'dan J'ye ortalama değişim hızı

Buna gore I, II ve III değerlerinin büyükten küçüğe doğru sıralanışı hangi şıkta doğru olarak verilmiştir?

A) I >II>III B) II>I>III C) I>III>II D) III>II>I E) III>I>II

14) Aşağıda bir fonksiyonun grafiği kesikli eğri ile ve bu grafiği belirtilen noktada kesen doğrular siyah doğrular ile gösterilmiştir.



Bu doğruların eğriye teğet olup olmadığını belirlemek için verilen bilgilerin hangisi veya hangileri kullanılmalıdır? Aşağıdaki tabloda (✓) işaretleyiniz.

Bilgi	
Fonksiyon	
Teğet doğrusu	
Sağ taraflı limit	
Sol taraflı limit	
Sekant doğruları	

15) Bir kaptaki suya çeşitli aralıklarla şeker eklenerek karıştırılıyor ve şeker oranı ölçülüyor.

y: Sudaki şeker miktarı ve

x: Zaman

olduğuna göre, $\frac{\Delta y}{\Delta x}$ **sembolü aşağıdakilerden hangisidir?**

A) Sudaki şeker oranı
B) Sudaki anlık şeker miktarı
C) Sudaki ortalama şeker miktarı
D) Sudaki şekerin anlık erime hızı
E) Sudaki şekerin ortalama erime hızı

16) $\lim_{x \to -2} \frac{x^3+8}{x+2}$ **ifadesinin değeri kaçtır?**

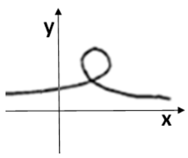
A) 0 B) 4 C) 8 D) 12 E) Belirsiz

17) Aşağıda bazı ifadeler verilmiştir. **Verilen ifadelerin bir <u>fonksiyon belirtip belirtmediğini</u> aşağıda (✓) işaretleyiniz.**

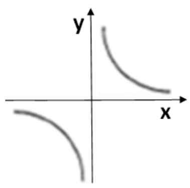
I. $y = 4sinx$ ....fonksiyon: belirtir ☐ belirtmez ☐

II. $y = \frac{4x^2+7x}{x^3-5}$ ....fonksiyon: belirtir ☐ belirtmez ☐

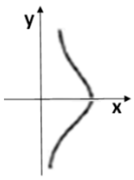
III. $\{(-3,1), (-2,2), (0,0), (2,7), (3,1)\}$................fonksiyon: belirtir ☐ belirtmez ☐

IV. 

..................................fonksiyon: belirtir ☐ belirtmez ☐

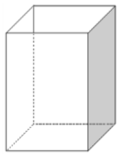
V. 

..................................fonksiyon: belirtir ☐ belirtmez ☐

VI.  ....fonksiyon: belirtir ☐ belirtmez ☐

PART II
DERIVATIVE TEST

18) <u>Problem:</u> Üstü açık ve tabanı kare olan dikdörtgenler prizması şeklindeki bir kutunun toplam yüzey alanı 48 cm^2'dir. Bu kutunun sahip olabileceği en büyük hacim kaç cm^3'dür?



Yukarıdaki problemi çözmek için <u>kesinlikle</u> bilinmesi gereken bilgiyi / bilgileri aşağıdaki tabloda işaretleyiniz.

I. Kutunun yüksekliği
II. Kutunun taban alanı
III. Kutunun hacim formülü
IV. Kutunun yüzey alan formülü
V. Kutunun hacminin, yüksekliğine göre türevi

Bilgi:	I.	II.	III.	IV.	V.

19) **Türevlenebilir bir f fonksiyonu için $f'(a)$ hangisi olabilir?**

I. $\lim_{h\to 0}\frac{f(a+h)-f(a)}{h}$
II. $\lim_{x\to a}\frac{f(x)-f(a)}{x-a}$
III. $\lim_{h\to 0}\frac{f(x+h)-f(x)}{h}$

A) I B) II C) I ve II D) I ve III E) II ve III

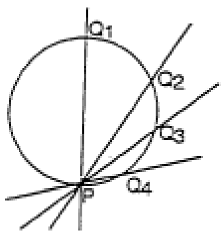
20) **Aşağıdaki fonksiyonların hangileri $[-2, 3]$ aralığında türevlenebilirdir? Tabloda işaretleyiniz.**

Fonksiyon	**$[-2,3]$ aralığında**
$f(x)=\dfrac{x^2+5x}{3x-7}$	Türevlenebilir ☐ Türevlenemez ☐
$g(x)=\lvert x+4\rvert$	Türevlenebilir ☐ Türevlenemez ☐
$h(x)=\dfrac{\lvert x-5\rvert}{x-5}$	Türevlenebilir ☐ Türevlenemez ☐
$k(x)=\dfrac{\sqrt{2x-7}}{x+3}$	Türevlenebilir ☐ Türevlenemez ☐
$l(x)=\begin{cases}5x^3+1, x\geq 1\\ 5x+7, x<1\end{cases}$	Türevlenebilir ☐ Türevlenemez ☐

21) $5x^3+7x-x^2$ **ifadesinin türevini yazınız.**

---

22) Aşağıdaki şekilde bir çember ve üzerindeki sabit bir P noktası gösteriliyor. PQ doğruları, çember üzerindeki P noktasından Q noktalarına şekildeki gibi çiziliyor ve her iki yönde doğru uzuyor. Bu şekildeki doğrular, ***sekant doğruları*** (***secant lines***) olarak adlandırılmaktadır.



Buna göre, Q noktası, P noktasına çok yaklaştıkça, sekant doğruları için ne söylenebilir?

A) Kısalır

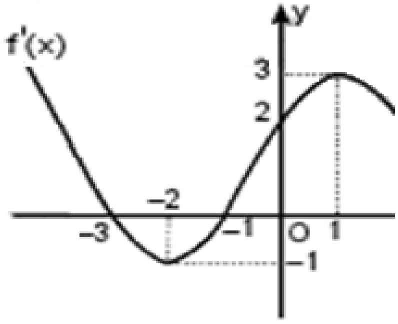
B) Yok olur

C) Bir noktaya dönüşür

D) Alan gittikçe küçülür

E) Teğet doğrusuna dönüşür

23) Aşağıda her noktada türevlenebilir bir <u>f fonksiyonunun türevinin (f'nün)</u> grafiği verilmiştir.



Yukarıdaki verilere uygun olarak alınacak her f fonksiyonu için **aşağıdakilerden hangisi kesinlikle doğrudur?**

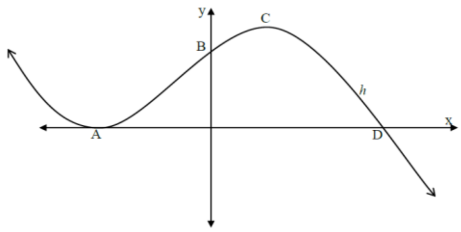
A) $-2 < x < -1$ aralığında artandır
B) $0 < x < 3$ aralığında azalandır
C) $x = 1$ de bir yerel maksimumu vardır
D) $x = -1$ de bir yerel maksimumu vardır
E) $x = -3$ de bir yerel maksimumu vardır

24) **Aşağıdaki ifadenin doğru olup olmadığını işaretleyiniz (✓) .**

I. $\frac{dy}{dt} = \frac{dy}{du}\frac{du}{dt}$ 'dir çünkü sadeleştirme işlemi yapıldığında $\frac{dy}{\cancel{du}}\frac{\cancel{du}}{dt} = \frac{dy}{dt}$ olur.......**D** ☐ **Y** ☐
II. Bir f fonksiyonunun türevi $f': A \to B$ şeklinde bir fonksiyondur..................**D** ☐ **Y** ☐
III. $\frac{dy}{dx}$ iki sonsuz küçük (infinitesimal) değişkenin oranıdır.............................. **D** ☐ **Y** ☐
IV. $\lim_{x\to -2} \frac{x^3+8}{x+2} = f'(2)$ olacak şekilde bir f fonksiyonu bulunabilir...............**D** ☐ **Y** ☐
V. $f(x) = 3x^2 + 3$ fonksiyonunun türevi $\lim_{h\to 0} 3(2x+h)$ şeklinde yazılabilir.........**D** ☐ **Y** ☐

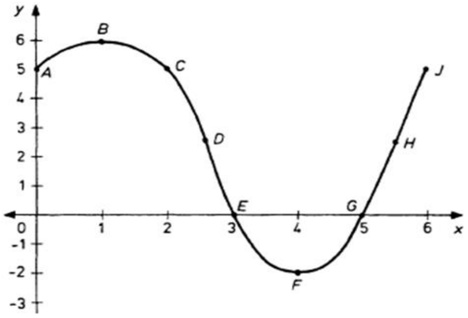
25) Aşağıda bir f fonksiyonunun grafiği verilmiştir.

$$f(x) = -x^3 + 3x + 2 = (x+1)^2(2-x)$$



Buna göre C noktasının koordinatlarını belirleyiniz.

26) Aşağıda $x \in [0,6]$ aralığında bir fonksiyonun grafiği görülmektedir



Belli noktalarda, y'nin x'e gore ortalama değişim hızı (average rate of change) aşağıdaki gibidir:

v_B: B noktasındaki değişim hızı (rate of change at B),
v_C: C noktasındaki değişim hızı (rate of change at C),
v_E: E noktasındaki değişim hızıdır (rate of change at E).

Buna gore v_A, $v_B$ve v_C değerlerinin sıralanışı aşağıdakilerden hangi şıkta doğru olarak verilmiştir?

A) $v_B > v_C > v_E$
B) $v_C > v_B > v_E$
C) $v_E > v_C > v_B$
D) $v_C > v_E > v_B$
E) $v_B > v_E > v_C$

27) $\frac{dy}{dx}$ **sembolü hangisini ifade etmektedir?**

A) y'nin x'e oranı
B) Δy'nin Δx'e oranı
C) x'e göre ortalama değişim
D) $\Delta x \to 0$ iken $\frac{\Delta y}{\Delta x}$ oranının limiti
E) $\Delta x \to \infty$ iken $\frac{\Delta y}{\Delta x}$ oranının limiti

28) Bir kuyuya atılan bir taşın zamana göre konumu $s = 5t^2 - 3t$ formülü ile veriliyor.

Bu taşın $t = 2$ sn'deki hızı nedir?

A) 14 B) 17 C) 20 D) 23 E) 26

29) Bir kaptaki suya çeşitli aralıklarla şeker eklenerek karıştırılıyor ve şeker oranı ölçülüyor.

y: Sudaki şeker miktarı ve

x: Zaman

olduğuna göre, $\lim_{\Delta x \to 0} \frac{\Delta y}{\Delta x}$ **sembolü hangisidir?**

A) Sudaki şeker oranı
B) Sudaki anlık şeker miktarı
C) Sudaki ortalama şeker miktarı
D) Sudaki şekerin anlık erime hızı
E) Sudaki şekerin ortalama erime hızı

APPENDIX F

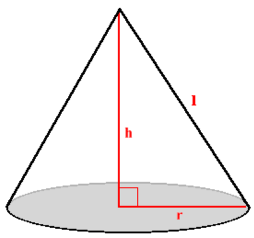
ANSWER KEY FOR THE DERIVATIVE ACHIEVEMENT TEST

1. **Aşağıdaki sorudaki boşluğu uygun ifade ile doldurunuz.**

$a, b, c, d \epsilon \mathbb{R} - \{0\}$ olmak üzere

$\frac{abcb}{dbca}$ ifadesi en sade biçimde, $\frac{b}{d}$ şeklinde yazılır.

2. Dairenin yarıçapı, koninin yanal yüzey uzunluğudur.



Bu durumda, $l = 10\ cm$ olur. $r^2 + h^2 = l^2$ olduğuna göre, $r^2 + h^2 = 10^2 = 100$ olur.

$V = \frac{1}{3}\pi r^2 h$ olduğuna göre, $V = \frac{1}{3}\pi r^2 h = \frac{1}{3}\pi(100 - h^2)h$ ya da aynı eşitlik

$V = \frac{1}{3}\pi(100h - h^3) = \frac{100}{3}\pi h - \frac{1}{3}\pi h^3$ eşitliklerinden biri ile ifade edebilir.

3. $\frac{\Delta y}{\Delta x}$ **sembolü aşağıdakilerden hangisini ifade etmektedir?**

A) İki değişim miktarının oranı

4. $4x^2 + 5x^3 + 2x + 1$ **polinomunun derecesi kaçtır?**

C)3

5. **Sonsuz küçük (infinitesimals) kavramını aşağıdakilerden hangisi en iyi tanımlamaktadır?**

C) Ölçülemeyecek küçüklükteki sayılar

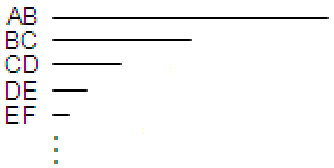
6. $(3(x + k)^2 + 2) - (3x^2 + 2)$ **ifadesini en sade şekilde belirtiniz.**

$(3(x + k)^2 + 2) - (3x^2 + 2) = 3(x^2 + 2xk + k^2) + 2 - 3x^2 - 2 = 3x^2 + 6xk + 3k^2 + 2 - 3x^2 - 2 = 6xk + 3k^2$

7. Sigara içmenin ve aşırı stresin kanser olmayı etkilediğini düşünen bir araştırmacı, bu durumla ilgili bir araştırma yapmak istiyor. **Bu araştırma için kullanılacak <u>bağımlı ve bağımsız değişkenler sırasıyla</u> hangi seçenekte doğru olarak verilmiştir?**

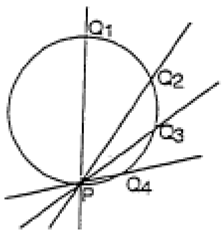
C) Kanser, Sigara

8. Uzunluğu 1 *birim* olan AB doğru parçasına, uzunluğu $\frac{1}{2}$ *birim* olan bir BC doğru parçası ekleniyor. Aynı yöntemle bu parçalara uzunlukları sırasıyla $\frac{1}{4}, \frac{1}{8}, \frac{1}{16}, \ldots$ *birim* olan şekildeki gibi CD, DE, EF,… şeklinde doğru parçaları ekleniyor. **Doğru parçalarının uzunluğu sıfıra yaklaştıkça AB+BC+CD+DE+EF+... parçalarının toplamı için aşağıdakilerden hangisidir?**



C) 2’ye yakınsar

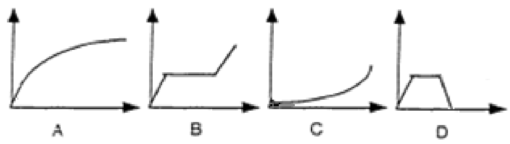
9. Aşağıdaki şekilde bir çember ve üzerindeki sabit bir P noktası gösteriliyor. PQ doğruları, çember üzerindeki P noktasından Q noktalarına çiziliyor ve her iki yönde uzuyor. Bu şekildeki doğrular, ***sekant doğruları*** (***secant lines***) olarak adlandırılmaktadır.



Şekilde görülen doğrular dışında kaç farklı sekant doğrusu çizilebilir?

E) ∞

10. Aşağıda verilen grafiklerde, x-ekseni zamanı, y-ekseni ise evden uzaklığı belirtmektedir.

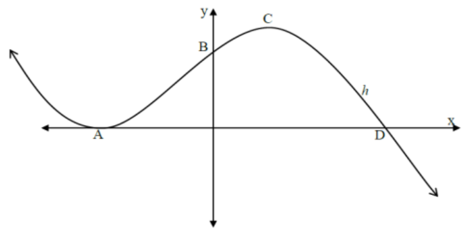


Evden ayrılmıştım ki kitaplarımı unuttuğumu fark ettim ve kitaplarımı almak için geri döndüm	D
Son durakta otobüsten indim ve yola yürüyerek devam ettim	A
Arabanın lastiği patlayıncaya kadar bir sorun yoktu	B

Sakin bir şekilde yola başladım fakat geç kalacağımı anladığımda hızlandım	C

11. Aşağıda bir f fonksiyonunun grafiği verilmiştir.

$f(x) = -x^3 + 3x + 2 = (x+1)^2(2-x)$



Buna göre <u>B noktasının koordinatları</u>nı belirleyiniz.

B=(0,2)

12. $f(x) = \begin{cases} 3x^2, x \ \square\ 1 \\ 4x, x \ \square\ 1 \end{cases}$ fonksiyonu veriliyor.

$f(1)$ değerini bulmak için $\square$ yerine yazılabilecek işaretler sırasıyla hangisi olabilir?

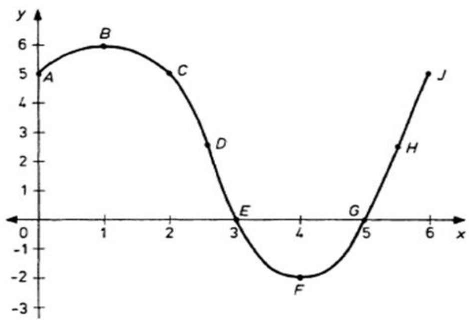
I. $>, <$

II. $\geq, <$

III. $=, <$

D) II ve III

13. Aşağıda $x \in [0,6]$ aralığında bir fonksiyonun grafiği görülmektedir.



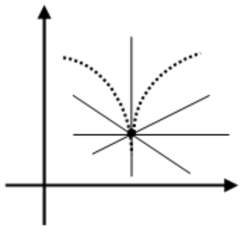
Belli noktalardaki, y'nin x'e gore ortalama değişim hızı (average rate of change) aşağıdaki gibidir:

I. A'dan B'ye ortalama değişim hızı
II. B'den E'ye ortalama değişim hızı
III. A'dan J'ye ortalama değişim hızı

Buna gore I, II ve III değerlerinin büyükten küçüğe doğru sıralanışı hangi şıkta doğru olarak verilmiştir?

C) I>III>II

14. Aşağıda bir fonksiyonun grafiği kesikli eğri ve bu grafiği belirtilen noktada kesen doğrular siyah doğrular ile gösterilmiştir.



Bu doğruların eğriye teğet olup olmadığını belirlemek için verilen bilgilerin hangisi veya hangileri kullanılmalıdır? (Lütfen aşağıdaki tabloda işaretleyiniz)

Bilgi	
Eğim	-
Fonksiyon	-
Sağ taraflı limit	+
Sol taraflı limit	+
Sekant doğruları	-

15. Bir kaptaki suya çeşitli aralıklarla şeker eklenerek karıştırılıyor ve şeker oranı ölçülüyor.
y: Sudaki şeker miktarı ve
x: Zaman
olduğuna göre, $\frac{\Delta y}{\Delta x}$ **sembolü aşağıdakilerden hangisidir?**

E)Sudaki şekerin ortalama erime hızı

16. $\lim_{x \to -2} \frac{x^3+8}{x+2}$ **ifadesinin değeri kaçtır?**

D) 12

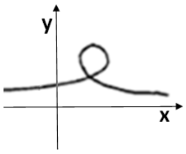
17. Aşağıda bazı ifadeler verilmiştir. **Verilen ifadelerin bir fonksiyon belirtip belirtmediğini aşağıdaki tabloda belirleyiniz.**

Ifade ***Fonksiyon belirtir***

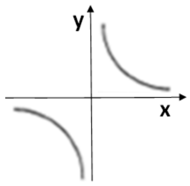
$y = 4sinx$ ………………………..……......**(D)**

$y = \frac{4x^2+7x}{x^3-5}$ …………………………………**(D)**

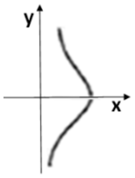
$\{(-3,1), (-2,2), (0,0), (2,7), (3,1)\}$…..………**(D)**



………………………..…....**(Y)**



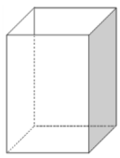
……………………………..(D)



…..……………………..……… (Y)

18. Problem: Üstü açık ve tabanı kare olan dikdörtgenler prizması şeklindeki bir kutunun toplam yüzey alanı 48 cm^2'dir. Bu kutunun sahip olabileceği en büyük hacim kaç cm^3'dür?

Yukarıdaki problemi çözmek için kesinlikle bilinmesi gereken bilgilerin aşağıdaki tabloda işaretleyiniz.



I. Kutunun yüksekliği
II. Kutunun taban alanı
III. Kutunun hacim formülü
IV. Kutunun yüzey alan formülü
V. Kutunun hacminin, yüksekliğine göre türevi

Bilgi:	I.	II.	III.	IV.	V.
	-	-	+	+	+

19. **Türevlenebilir bir f fonksiyonu için $f'(a)$ hangisi olabilir?**

I. $\lim_{h\to 0}\frac{f(a+h)-f(a)}{h}$

II. II. $\mathrm{Lim}_{x\to a}\frac{f(x)-f(a)}{x-a}$

III. III. $\lim_{h\to 0}\frac{f(x+h)-f(x)}{h}$

A) B) II C) I ve D) I ve E) II ve III

20. **Aşağıdaki fonksiyonların hangilerinin $[-2,3]$ aralığında türevlenebilir olduğunu verilen tabloda işaretleyiniz.**

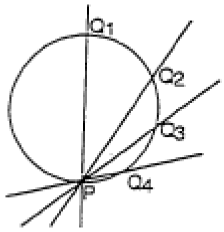
Fonksiyon	**$[-2,3]$ aralığında**
$f(x)=\dfrac{x^2+5x}{3x-7}$	Türevlenemez☐
$g(x)=\lvert x+4\rvert$	Türevlenemez☐

$h(x) = \dfrac{\lvert x-5 \rvert}{x-5}$	Türevlenebilir□
$k(x) = \dfrac{\sqrt{2x-7}}{x+3}$	Türevlenebilir□
$l(x) = \begin{cases} 5x^3+1, x \geq 1 \\ 5x+7, x < 1 \end{cases}$	Türevlenemez□

21. $5x^3 + 7x - x^2$ **ifadesinin türevini yazınız.**

$15x^2 + 7 - 2x$

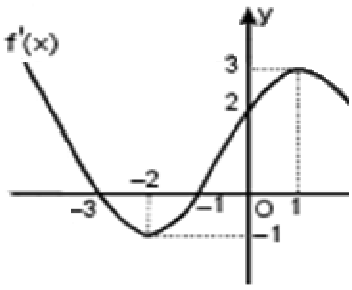
22. Aşağıdaki şekilde bir çember ve üzerindeki sabit bir P noktası gösteriliyor. PQ doğruları, çember üzerindeki P noktasından Q noktalarına şekildeki gibi çiziliyor ve her iki yönde doğru uzuyor. Bu şekildeki doğrular, ***sekant doğruları*** (***secant lines***) olarak adlandırılmaktadır.



Buna göre, Q noktası, P noktasına çok yaklaştıkça, sekant doğruları için ne söylenebilir?

E)Eğim doğrusuna dönüşür

23. Aşağıda her noktada türevlenebilir bir f fonksiyonunun türevinin (f'nün) grafiği verilmiştir.



Yukarıdaki verilere uygun olarak alınacak <u>her f fonksiyonu</u> için aşağıdakilerden hangisi <u>kesinlikle doğrudur</u>?

E)$x = -3$ de bir yerel maksimumu vardır

24. **Aşağıdaki ifadenin doğru olup olmadığını belirleyiniz.**

I. $\frac{dy}{dt}=\frac{dy}{du}\frac{du}{dt}$ 'dir çünkü sadeleştirme işlemi yapıldığında $\frac{dy}{du}\frac{du}{dt}=\frac{dy}{dt}$ olur **(Y)**

II. Bir f fonksiyonunun türevi $f': A \to B$ şeklinde bir fonksiyondur **(D)**

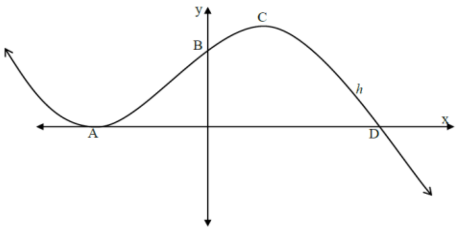
III. $\frac{dy}{dx}$ iki sonsuz küçük (infinitesimal) değişkenin oranıdır **(D)**

IV. $\lim_{x\to -2}\frac{x^3+8}{x+2}=f'(2)$ olacak şekilde bir f fonksiyonu bulunabilir. **(D)**

V. $f(x)=3x^2+3$ fonksiyonunun türevi $\lim_{h\to 0}3(2x+h)$ şeklinde yazılabilir. **(D)**

25. Aşağıda bir f fonksiyonunun grafiği verilmiştir.

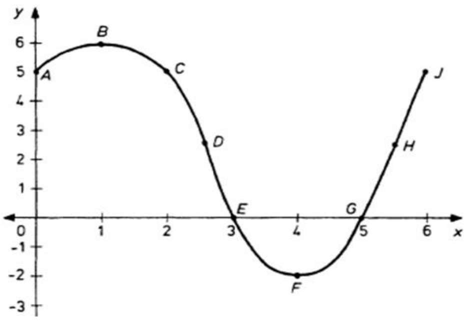
$f(x)=-x^3+3x+2=(x+1)^2(2-x)$



Buna göre <u>C noktasının koordinatları</u> belirleyiniz.

C=(1,4)

26. Aşağıda $x \in [0,6]$ aralığında bir fonksiyonun grafiği görülmektedir.



Belli noktalarda, y'nin x'e gore ortalama değişim hızı (average rate of change) aşağıdaki gibidir:

v_B: B noktasındaki değişim hızı,
v_C: C noktasındaki değişim hızı,
v_E: E noktasındaki değişim hızıdır.

Buna gore v_A, v_Bve v_C değerlerinin sıralanışı aşağıdakilerden hangisinde doğru olarak verilmiştir?

A) $v_B > v_C > v_E$

27. $\frac{dy}{dx}$ **sembolü hangisini ifade etmektedir?**

D) $\Delta x \to 0$ iken $\frac{\Delta y}{\Delta x}$ oranının limiti

28.

Bir kuyuya atılan bir taşın zamana göre konumu $s = 5t^2 - 3t$ formülü ile veriliyor.

Bu taşın $t = 2$ sn'deki hızı nedir?

B) 17

29. Bir kaptaki suya çeşitli aralıklarla şeker eklenerek karıştırılıyor ve şeker oranı ölçülüyor.

y: Sudaki şeker miktarı ve

x: Zaman

olduğuna göre, $\frac{dy}{dx}$ **sembolü hangisidir?**

D)Sudaki şekerin anlık erime hızı

APPENDIX G

ETHICAL PERMISSION

1956

Orta Doğu Teknik Üniversitesi
Middle East Technical University

Öğrenci İşleri Daire Başkanlığı
Registrar's Office

06531 Ankara, Türkiye
Phone: +90 (312) 2103417
Fax: +90 (312) 2107960
www.oidb.metu.edu.tr

B.30.2.ODT.72.00.00/400 -1760 -465 04/04/2012

EĞİTİM FAKÜLTESİ DEKANLIĞINA

Üniversitemiz Ortaöğretim Fen ve Matematik Eğitimi Ana Bilim Dalı Doktora Programı öğrencisi Fulya Kulu'ya ait Etik Komite onay yazısı ilgisi nedeni ile ekte sunulmuştur.

Gereğini bilgilerinize arz ederim.

Saygılarımla.

Nesrin Ünsal
Öğrenci İşleri Daire Başkanı

Ekler:
1- İAEK Başvuru Formu
2-İAEK Başvuru Kontrol Listesi
3-İAEK Başvuru Formu Proje Bilgi Formu
4-Anket

SSD/

Orta Doğu Teknik Üniversitesi İnsan Araştırmaları
Etik Kurulu Başvuru Formu

Orta Doğu Teknik Üniversitesi (ODTÜ) bünyesinde yapılan ve/ya ODTÜ çalışanları/öğrencileri tarafından yürütülen ve insan katılımcılardan bilgi toplamayı gerektiren tüm çalışmalar, ODTÜ İnsan Araştırmaları Etik Kurulu incelemesine tabidir. Bu başvuru formu doldurulduktan sonra diğer gerekli belgelerle birlikte ODTÜ İnsan Araştırmaları Etik Kuruluna başvuru yapılmalıdır. Çalışmalar, Etik Kurulun onayının alınmasından sonra aktif olarak başlatılmalıdır.

1. Araştırmanın başlığı: Öğrencilerin Genel Matematiği Kavraması (Students' Conception of Calculus)
2. Araştırmanın niteliği (Uygun olan kutuyu işaretleyiniz) ☐ Öğretim Üyesi Araştırması ■ Doktora Tezi
   ☐ Yüksek Lisans Tezi ☐ Diğer (belirtiniz) ________________
3. Araştırmacının/Araştırmacıların:
   Adı-Soyadı: Fulya KULA Bölümü: Ortaöğretim Fen ve Matematik Alanları Eğitimi
   Telefonu: 0 505 499 40 79
   Adresi: Orta Doğu Teknik Üniversitesi, Eğitim Fakültesi, 2. Kat, No:204, Cankaya, Ankara
   E-posta adresi: fkula@metu.edu.tr
4. Danışmanın: Adı-Soyadı: Giray Berberoğlu Telefonu: 0312 210 41 89
5. Veri Toplanacak Dönem: Başlangıç 01/Nisan/2012 Bitiş :30/Ağustos/2012
6. Veri Toplanması Planlanan Yerler/Mekanlar, Kurum ve Kuruluşlar:
   a. Orta Doğu Teknik Üniversitesi
   b. Ankara Üniversitesi
   c. Hacettepe Üniversitesi
   d. Gazi Üniversitesi
   e. Aksaray Üniversitesi
   f. Amasya Üniversitesi
   g.TOBB Ekonomi ve Teknoloji Üniversitesi
   h.Düzce Üniversitesi
7. Çalışmanın/Projenin desteklenip desteklenmediği: ■ Desteksiz ☐ Destekli
   Desteklenen bir proje ise, destekleyen kurum: ☐ Üniversite ☐ TUBİTAK
   ☐ Uluslararası (belirtiniz) ____________________ ☐ Diğer (belirtiniz) ____________________
8. Başvurunun statüsü: ■Yeni başvuru ☐ Revize edilmiş başvuru ☐ Bir önceki projenin devamı
   Bir önceki projenin devamı ise, yürütülen çalışma önceden onaylanan çalışmadan herhangi bir farklılık gösteriyor mu? ☐ Evet ☐ Hayır
   Evet ise açıklayınız:____

* Lisans Öğrencilerinin araştırmalarını yönlendiren akademik danışmanlarının veya hocalarının olması gerekmektedir.

Bu bölüm ilgili bölümleri temsil eden İA Etik Alt Kurulu tarafından doldurulacaktır.

Project No: 2012– EGT– 030

İAEK DEĞERLENDİRME SONUCU

Sayın Hakem,

Aşağıda yer alan üç seçenekten birini işaretleyerek değerlendirmenizi tamamlayınız. Lütfen ikinci ("Revizyon Gereklidir") ve üçüncü ("Ret") değerlendirmeleri için gerekli açıklamaları yapınız.

Değerlendirme Tarihi: **20.03.2012** **İmza:**

1.	**Herhangi bir değişikliğe gerek yoktur. Veri toplama/uygulama başlatılabilir** __X___
2.	**Revizyon gereklidir** _______ a. Gönüllü Katılım Formu Yoktur _______ b. Gönüllü Katılım Formu Eksiktir _______ Açıklama: c. Katılım sonrası bilgilendirme formu yoktur _______ d. Katılım sonrası bilgilendirme formu eksiktir_______ Açıklama: e. Rahatsizlık kaynağı olabilecek sorular/maddeler ya da prosedürler içerilmektedir. _______ Açıklama: f. Diğer _______ Açıklama:
3.	**Ret** _______ Açıklama:

9 Çalışma katılımcılara, herhangi bir şekilde yanlı/yanlış bilgi vermeyi, çalışmanın amacını tamamen gizli tutmayı gerektiriyor mu? □Evet ■ Hayır

Evet ise açıklayınız:____

10. Çalışma katılımcıların fiziksel veya ruhsal sağlıklarını tehdit edici sorular/maddeler, prosedürler ya da manipülasyonlar/uygulamalar içeriyor mu? □ Evet ■ Hayır

Evet ise açıklayınız:____

11. Katılımcı sayısı: 2000
12. Kontrol grup kullanılacak mı?: □ Evet ■ Hayır
13. Aşağıda sunulan listeden, çalışmanın katılımcılarını en iyi tanımlayan seçenekleri işaretleyiniz.

■ Üniversite Öğrencileri

Çalışan Yetişkinler

Halihazırda İş Sahibi Olmayan Yetişkinler

Okul Öncesi Çocuklar

İlköğretim Öğrencileri

Lise Öğrencileri

Çocuk İşçiler

Yaşlılar

Zihinsel Engelli Bireyler

Fiziksel Engelli Bireyler

Tutuklular

Diğer (belirtiniz) __________________

14. Aşağıda yer alan uygulamalardan, çalışma kapsamında yer alacak olanları işaretleyiniz.

■ Anket

Mülakat

Gözlem

Bilgisayar ortamında test uygulamak

Video/film kaydı

Ses kaydı

Alkol, uyuşturucu ya da diğer herhangi bir kimyasal maddenin katılımcılara kullandırılması

Yüksek düzeyde uyarıma (ışık, ses gibi) maruz bırakma

Radyoaktif materyale maruz bırakma

Diğer (belirtiniz):__________________________

APPENDIX H

SAMPLE CONSENT FORM

Gönüllü Katılım ve Bilgilendirme Formu

Bu çalışma Orta Öğretim Matematik Alanları Eğitimi doktora çalışmasının bir kısmı olarak öğrencilerin demografik bilgilerinin, çeşitli durumlardaki tutumla ve fikirlerinin ve türev konusundaki bilgilerinin düşünmeyle ilişkisini anlamaya yardımcı olmak üzere hazırlanmıştır.

Ölçekte katılımcılar ile ilgili olan ilk 12 soruya, ardından katılımcıların çeşitli durumlarla ilgili tutum ve fikirlerini içeren 49 soruya ve son olarak türev konusu ile ilgili 29 soruluk teste doğru seçeneğin işaretlemesi istenmektedir.

Bu çalışma matematik eğitim ve öğretimini geliştirmek, özellikle üniversite öğrencilerinin türev konusundaki bilgilerinin belirlenip iyileştirilmesi hedeflenmektedir.

Araştırma sırasında toplanan tüm kişisel bilgiler kesinlikle gizli tutulacaktır. Tüm veriler sadece araştırmacı tarafından saklanacak ve sadece çalışma kapsamında kullanılacaktır. Kimliğinizi açığa çıkaracak üniversite, bölüm, sınıf, cinsiyet, not ortalaması gibi kişisel bilgiler kesinlikle gizli tututulacaktır.

Çalışma hakkında bilgi almak için araştırmacıya aşağıdaki kanallardan ulaşabilirsiniz:

Fulya KULA
fkula@metu.edu.tr
Tlf: 0090 312 210 3686
ODTÜ Eğitim Fakültesi
Ortaöğretim Fen ve Matematik Alanları Eğitimi Bölümü
2. Kat No: 204
06800 ODTÜ –ANKARA

Bu çalışmaya katılımınız kesinlikle gönüllü olup istediğiniz takdirde çalışmanın herhangi bir aşamasında hiçbir koşul olmaksızın çalışmaya katılmaktan vazgeçebilirsiniz. Çalışma sonlandırılmadan vazgeçtiğiniz takdirde verdiğiniz bilgiler kullanılmayıp imha edilecektir. Çalışmaya katılım tamamen gönüllü olup verdiğinizi bilgiler sizin için kesinlikle risk teşkil etmemektedir.

Yukarıdaki bilgileri okudum. Çalışmaya gönüllü olarak katılmak istiyorum.

Tarih:

Katılımcı:

İmza:

APPENDIX I

THE SIMPLIS SYNTAXX FOR THE CFA OF THE AFFCTIVE MODEL

Confirmatory Factor Analysis of the Affective Model

```
CFA-Affective
 Raw Data from file 'C:\Users\user\Desktop\2\LAST.psf'
 Latent Variables  SES MOTIV SANX TANX SELF
 Relationships
 HOMEPC EVKITAP  INTERNET SELFPC MOTHERED FATHERED = SES
 MOTIV1  MOTIV2 MOTIV3 MOTIV4 MOTIV5 MOTIV10= MOTIV
 ANX1 ANX2 ANX3 ANX4 ANX5 ANX6 ANX7 ANX8 ANX9 ANX10 ANX11 ANX12
ANX13 ANX14 ANX15= SANX
 ANX16 ANX17 ANX18 ANX19 ANX21 ANX22 ANX23 ANX25 ANX27 ANX28
ANX29 ANX30 = TANX
 SELFEF1 SELFEF2 SELFEF3 SELFEF4 SELFEF5 SELFEF6 SELFEF7 SELFEF8 =
SELF
 Number of Decimals = 3
 Admissibility Check = Off
 Iterations = 5000
 Print Residuals
 Path Diagram
 Let the Errors of FATHERED and MOTHERED Correlate
 Let the Errors of ANX5 and ANX4 Correlate
 Let the Errors of SELFEF3 and SELFEF2 Correlate
 Let the Errors of ANX17 and ANX16 Correlate
 End of Problem
```

APPENDIX J

THE MEASUREMENT COEFFICIENTS AND ERROR VARIANCES FOR THE SURVEY

Latent Variables	Observed Variables	λ_Y	ε
social anxiety	anxiety3	0.859	0.693
	anx12	0.933	0.472
	anxiety4	0.908	0.887
	anxiety1	0.874	0.763
	anxiety2	0.906	0.682
	anxiety5	0.865	1.231
	anx10	0.764	0.715
	anxiety9	0.827	0.838
	anx15	0.713	0.851
	anxiety7	0.731	0.976
	anxiety8	0.775	1.157
	anxiety6	0.663	1.349
	anx11	0.705	1.146
	anx14	0.559	1.112
	anx13	0.462	0.823
test anxiety	anx28	0.580	0.234
	anx30	0.569	0.245
	anx29	0.551	0.226
	anx21	0.574	0.360
	anx17	0.373	0.377
	anx16	0.424	0.481
	anx19	0.538	0.589
	anx18	0.406	0.641
	anx27	0.483	0.395
	anx22	0.743	0.937
	anx23	0.631	0.948
	anx25	0.601	0.812
Self Efficacy	selfef6	0.813	0.229
	selfef5	0.765	0.271
	selfef4	0.750	0.302
	selfef3	0.479	0.358
	selfef2	0.422	0.421
	selfef8	0.601	0.596
	selfef1	0.461	0.473
	selfef7	0.597	0.619
Socioeconomic status	mothered	0.948	1.306
	fathered	0.997	1.336
	famincome	0.810	1.126

	internet	0.158	0.131
	homepc	0.0943	0.0867
	kkitap	0.474	0.979
	selfpc	0.111	0.137
Motivation	motiv2	0.699	0.550
	motiv3	0.673	0.454
	motiv4	0.562	0.734
	motiv1	0.617	0.671
	motiv10	0.523	0.798
	motiv5	0.590	0.950

APPENDIX K

SUMMARY STATISTICS FOR THE CFA MODEL OF THE SURVEY TEST

SUMMARY STATISTICS OF FITTED, STANDARDIZED RESIDUALS, STEAM-LEAF AND Q PLOTS OF RESIDUALS FOR CFA OF THE SURVEY TEST

Summary Statistics for Fitted Residuals
Smallest Fitted Residual =   -0.261
Median Fitted Residual =   0.000
Largest Fitted Residual =   0.216

```
 Stemleaf Plot
 - 2|6
 - 2|331
 - 1|9876655555
 - 1|44444443333333332222222211111111110000000000
 -
0|9999999999999999888888888888888888888888877777777777777777777777666666+
73
 -
0|44444444444444444444444444444444444444444443333333333333333333333333+
99
0|1111111111111111111111111111111111111111111111111111111111111111111111+
90
0|55555555555555555555555555556666666666666677777777777788888888888899999999+
04
   1|000000000000111111111122222222222333333333344444444444444
   1|555555666666666777888888888999999999
   2|00000111112223334
   2|555666899
   3|00012344
   3|6
   4|2
```

Summary Statistics for Standardized Residuals
Smallest Standardized Residual =   -9.500
Median Standardized Residual =   0.000
Largest Standardized Residual =   10.377

```
Stemleaf Plot
 - 8|54217776
 - 6|96311553330000
 - 4|9998886665544433332222110000009999888766555444333221111000
```

-
2|98888888887777766665555444444444433332222222211111111000000099999998888+
08
-
0|999999999999888888888888888888888877777777777777766666666666666655555555+
92
0|111111111111122222222222222222233333333333333333333444444444444455555555555+
91
2|000000000000111111111222222222233333333344444444445555555556666666777788999+
43
4|0001111222222233333555556667777777888899990123344566777777888
6|00000122335559901113578899
8|0224777011444579
10|011244560035
12|168456689
14|77911
16|458
18|504

APPENDIX L

GOODNES-OF-FIT CRITERIA FOR THE AFFECTIVE MODEL

Fit Index	**Criterion**	**Value**
Chi-Square (χ^2)	Non-significant	2708.695 (p<.00)
Normed Chi-Square (NC)	NC< 5	2,64
Goodness of Fit Index (GFI)	GFI> 0.90	0.934
Adjusted Goodness of Fit Index (AGFI)	AGFI> 0.90	0.924
Root Mean Square Error of Approximation (RMSEA)	0.05 < RMSEA < 0.08 (moderate fit) RMSEA < 0.05 (good fit)	0.0324
Root Mean Square Residual (RMR)	RMR < 0.05	0.0468
Root Mean Square Residual (SRMR)	S-RMR < 0.05	0.0468
Parsimony Goodness of Fit Index (PGFI)	Higher values	0.813
Parsimony Normed Fit Index (PNFI)	Higher values	0.880
Normed Fit Index (NFI)	NFI> 0.90	0.979
Non-Normed Fit Index (NNFI)	NNFI> 0.90	0.979
Comparative Fit Index (CFI)	CFI> 0.90	0.981
Incremental Fit Index (IFI)	IFI> 0.90	0.981
Relative Fit Index (RFI)	RFI> 0.90	0.967

APPENDIX M

THE QUESTIONS OF DAT APPEARED IN THE RESULTS

PRE 2)

Aşağıdaki soruda boşluğu uygun ifade ile doldurunuz.

$a, b, c, d \epsilon \mathbb{R} - \{0\}$ olmak üzere, $x = ab$, $y = bc$ ve $z = abcd$ ise

$\frac{xy}{z}$ ifadesi en sade biçimde __________ şeklinde yazılır.

PRE 7)

$4x^2 + 5x^3 + 2x + 1$ **polinomunun derecesi kaçtır?**

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

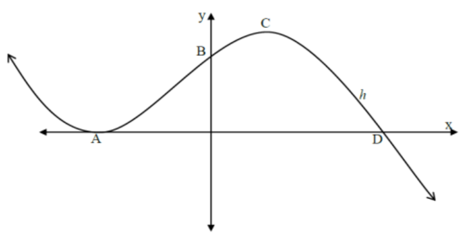
PRE 9)

$[3(x + k)^2 + 2] - (3x^2 + 2)$ **ifadesini en sade biçimde yazınız.**

PRE 17)

Aşağıda bir f fonksiyonunun grafiği verilmiştir.

$$f(x) = -x^3 + 3x + 2 = (x + 1)^2(2 - x)$$



Buna göre B noktasının koordinatlarını belirleyiniz.

PRE 3)

$\frac{\Delta y}{\Delta x}$ **sembolü aşağıdakilerden hangisini ifade etmektedir?**

A) İki değişim miktarının oranı
B) Bir noktadaki değişim oranı
C) Bir noktadaki eğim
D) Bir noktadaki limit

E) Basit kesir

PRE 4)

Bir kaptaki suya çeşitli aralıklarla şeker eklenerek karıştırılıyor ve şeker oranı ölçülüyor.

y: Sudaki şeker miktarı ve

x: Zaman

olduğuna göre, $\frac{\Delta y}{\Delta x}$ **sembolü aşağıdakilerden hangisidir?**

A) Sudaki şeker oranı
B) Sudaki anlık şeker miktarı
C) Sudaki ortalama şeker miktarı
D) Sudaki şekerin anlık erime hızı
E) Sudaki şekerin ortalama erime hızı

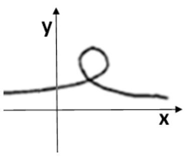
PRE 16)

Aşağıda bazı ifadeler verilmiştir. **Verilen ifadelerin bir <u>fonksiyon belirtip belirtmediğini</u> aşağıda (☑) işaretleyiniz.**

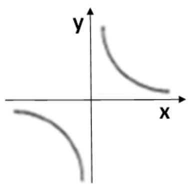
I. $y = 4sinx$ ....fonksiyon: belirtir ☐ belirtmez ☐

II. $y = \frac{4x^2+7x}{x^3-5}$ ....fonksiyon: belirtir ☐ belirtmez ☐

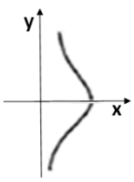
III. $\{(-3,1), (-2,2), (0,0), (2,7), (3,1)\}$................fonksiyon: belirtir ☐ belirtmez ☐



IV. ....fonksiyon: belirtir ☐ belirtmez ☐



V. ....fonksiyon: belirtir ☐ belirtmez ☐



VI. ....fonksiyon: belirtir ☐ belirtmez ☐

PRE 8)

$f(x) = \begin{cases} 3x^2, x\square\ 1 \\ 4x,\ x\square\ 1 \end{cases}$ fonksiyonu veriliyor.

$f(1)$ **değerini bulmak için** $\square$**yerine yazılabilecek işaretler sırasıyla hangisi olabilir?**

I. $>, <$
II. $\geq, <$
III. $=, <$

B) I B) II C) III D) II ve III E) I, II ve III

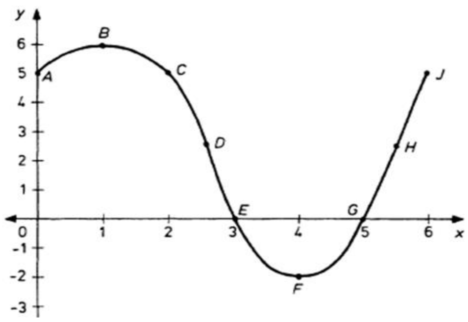
PRE 13)

Sigara içmenin ve aşırı stresin kanser olmayı etkilediğini düşünen bir araştırmacı, bu durumla ilgili bir araştırma yapmak istiyor. **Bu araştırma için kullanılacak <u>bağımlı ve bağımsız değişkenler, sırasıyla</u> hangi seçenekte doğru olarak verilmiştir?**

A) Stres, Kanser
B) Stres, Sigara
C) Kanser, Sigara
D) Sigara, Stres
E) Sigara, Kanser

PRE 15)

Aşağıda $x \in [0,6]$ aralığında bir fonksiyonun grafiği görülmektedir



Belli noktalarda, y'nin x'e gore ortalama değişim hızı (average rate of change) aşağıdaki gibidir:

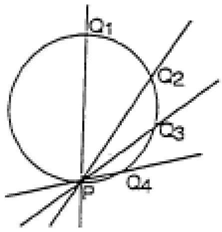
I. A'dan B'ye ortalama değişim hızı
II. B'den E'ye ortalama değişim hızı
III. A'dan J'ye ortalama değişim hızı

Buna gore I, II ve III değerlerinin büyükten küçüğe doğru sıralanışı hangi şıkta doğru olarak verilmiştir?

B) I >II>III B) II>I>III C) I>III>II D) III>II>I E) III>I>II

PRE 5)

Aşağıdaki şekilde bir çember ve üzerindeki sabit bir P noktası gösteriliyor. PQ doğruları, çember üzerindeki P noktasından Q noktalarına şekildeki gibi çiziliyor ve her iki yönde doğru uzuyor. Bu şekildeki doğrular, ***sekant doğruları*** (***secant lines***) olarak adlandırılmaktadır.

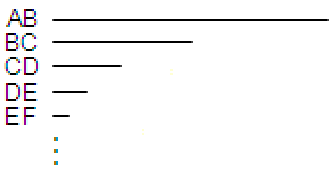


Şekilde görülen doğrular dışında kaç farklı sekant doğrusu çizilebilir?

A) 0 B) 1 C) 2 D) 4 E) ∞

PRE 6)

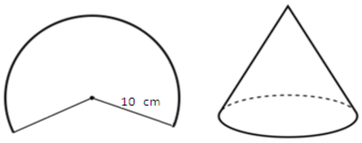
Uzunluğu 1 *birim* olan AB doğru parçasına, uzunluğu $\frac{1}{2}$ *birim* olan bir BC doğru parçası ekleniyor. Aynı yöntemle bu parçalara uzunlukları sırasıyla $\frac{1}{4}, \frac{1}{8}, \frac{1}{16}, \ldots$ *birim* olan şekildeki gibi CD, DE, EF,… doğru parçaları ekleniyor. **Doğru parçalarının uzunluğu sıfıra yaklaştıkça AB+BC+CD+DE+EF+... parçalarının toplamı için aşağıdakilerden hangisi söylenebilir?**



A) ∞
B) 2
C) 2’ye yakınsar
D) 2’den küçük bir sayı
E) 2’den büyük bir sayı

PRE 12)

Yarıçapı10 cm olan Şekil 1’deki gibi bir daire parçası bükülerek Şekil 2’deki gibi bir koni oluşturuluyor.



Şekil 1 Şekil 2

Buna göre koninin hacmini tek değişkenli olarak belirtiniz.

DRV 4)

Bir kuyuya atılan bir taşın zamana göre konumu $s = 5t^2 - 3t$ formülü ile veriliyor.

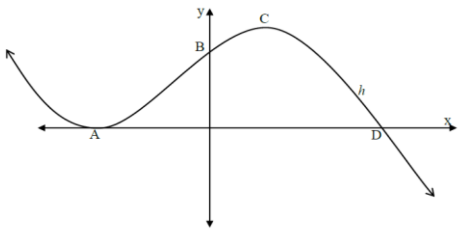
Bu taşın $t = 2$ sn'deki hızı nedir?

A) 14 B) 17 C) 20 D) 23 E) 26

DRV 14)

Aşağıda bir f fonksiyonunun grafiği verilmiştir.

$$f(x) = -x^3 + 3x + 2 = (x+1)^2(2-x)$$



Buna göre <u>C noktasının koordinatları</u>nı belirleyiniz.

DRV 15)

$5x^3 + 7x - x^2$ **ifadesinin türevini yazınız.**

DRV 9)

Türevlenebilir bir f fonksiyonu için $f'(a)$ hangisi olabilir?

I. $\lim_{h \to 0} \frac{f(a+h)-f(a)}{h}$

II. $\lim_{x \to a} \frac{f(x)-f(a)}{x-a}$

III. $\lim_{h \to 0} \frac{f(x+h)-f(x)}{h}$

B) I B) II C) I ve II D) I ve III E) II ve III

DRV 10)

Aşağıdaki fonksiyonların hangileri $[-2, 3]$ aralığında türevlenebilirdir? Tabloda işaretleyiniz.

Fonksiyon	**$[-2, 3]$ aralığında**
$f(x) = \dfrac{x^2 + 5x}{3x - 7}$	Türevlenebilir ☐ Türevlenemez ☐
$g(x) = \lvert x + 4 \rvert$	Türevlenebilir ☐ Türevlenemez ☐
$h(x) = \dfrac{\lvert x - 5 \rvert}{x - 5}$	Türevlenebilir ☐ Türevlenemez ☐
$k(x) = \dfrac{\sqrt{2x - 7}}{x + 3}$	Türevlenebilir ☐ Türevlenemez ☐
$l(x) = \begin{cases} 5x^3 + 1, x \geq 1 \\ 5x + 7, x < 1 \end{cases}$	Türevlenebilir ☐ Türevlenemez ☐

DRV 11)

$\boldsymbol{\dfrac{dy}{dx}}$ **sembolü hangisini ifade etmektedir?**

A) y'nin x'e oranı

B) Δy'nin Δx'e oranı

C) x'e göre ortalama değişim

D) $\Delta x \to 0$ iken $\dfrac{\Delta y}{\Delta x}$ oranının limiti

E) $\Delta x \to \infty$ iken $\dfrac{\Delta y}{\Delta x}$ oranının limiti

DRV 13)

Bir kaptaki suya çeşitli aralıklarla şeker eklenerek karıştırılıyor ve şeker oranı ölçülüyor.

y: Sudaki şeker miktarı ve

x: Zaman

olduğuna göre, $\lim_{\Delta x \to 0} \dfrac{\Delta y}{\Delta x}$ **sembolü hangisidir?**

A) Sudaki şeker oranı

B) Sudaki anlık şeker miktarı

C) Sudaki ortalama şeker miktarı

D) Sudaki şekerin anlık erime hızı

E) Sudaki şekerin ortalama erime hızı

DRV 2)

$\lim_{x \to -2} \dfrac{x^3+8}{x+2}$ **ifadesinin değeri kaçtır?**

A) 0 B) 4 C) 8 D) 12 E) Belirsiz

DRV 3)

Aşağıdaki ifadenin doğru olup olmadığını işaretleyiniz (✓) .

I. $\frac{dy}{dt} = \frac{dy}{du}\frac{du}{dt}$ 'dir çünkü sadeleştirme işlemi yapıldığında $\frac{dy}{du}\frac{\cancel{du}}{\cancel{dt}} = \frac{dy}{dt}$ olur.......**D** ☐ **Y** ☐

II. Bir f fonksiyonunun türevi $f'\colon A \rightarrow B$ şeklinde bir fonksiyondur.......................**D** ☐ **Y** ☐

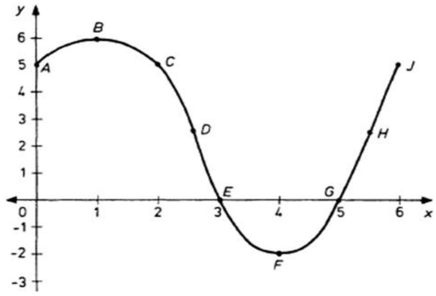
III. $\frac{dy}{dx}$ iki sonsuz küçük (infinitesimal) değişkenin oranıdır.................................... **D** ☐ **Y** ☐

IV. $\lim_{x \to -2} \frac{x^3+8}{x+2} = f'(2)$ olacak şekilde bir f fonksiyonu bulunabilir.......................**D** ☐ **Y** ☐

V. $f(x) = 3x^2 + 3$ fonksiyonunun türevi $\lim_{h \to 0} 3(2x + h)$ şeklinde yazılabilir....**D** ☐ **Y** ☐

DRV 8)

Aşağıda $x \in [0,6]$ aralığında bir fonksiyonun grafiği görülmektedir



Belli noktalarda, y'nin x'e gore ortalama değişim hızı (average rate of change) aşağıdaki gibidir:

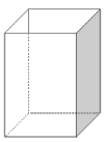
v_B: B noktasındaki değişim hızı (rate of change at B),
v_C: C noktasındaki değişim hızı (rate of change at C),
v_E: E noktasındaki değişim hızıdır (rate of change at E).

Buna gore v_A, v_Bve v_C değerlerinin sıralanışı aşağıdakilerden hangi şıkta doğru olarak verilmiştir?

A) $v_B > v_C > v_E$
B) $v_C > v_B > v_E$
C) $v_E > v_C > v_B$
D) $v_C > v_E > v_B$
E) $v_B > v_E > v_C$

DRV 1)

<u>Problem:</u> Üstü açık ve tabanı kare olan dikdörtgenler prizması şeklindeki bir kutunun toplam yüzey alanı 48 cm^2'dir. Bu kutunun sahip olabileceği en büyük hacim kaç cm^{3}'dür?



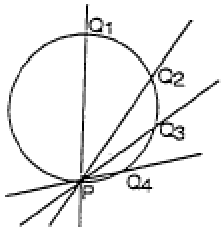
Yukarıdaki problemi çözmek için <u>kesinlikle</u> bilinmesi gereken bilgiyi / bilgileri aşağıdaki tabloda işaretleyiniz.

I. Kutunun yüksekliği
II. Kutunun taban alanı
III. Kutunun hacim formülü
IV. Kutunun yüzey alan formülü
V. Kutunun hacminin, yüksekliğine göre türevi

Bilgi:	I.	II.	III.	IV.	V.

DRV 6)

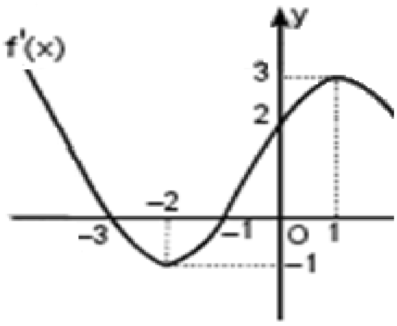
Aşağıdaki şekilde bir çember ve üzerindeki sabit bir P noktası gösteriliyor. PQ doğruları, çember üzerindeki P noktasından Q noktalarına şekildeki gibi çiziliyor ve her iki yönde doğru uzuyor. Bu şekildeki doğrular, ***sekant doğruları*** (***secant lines***) olarak adlandırılmaktadır.



Buna göre, Q noktası, P noktasına çok yaklaştıkça, sekant doğruları için ne söylenebilir?
A) Kısalır
B) Yok olur
C) Bir noktaya dönüşür
D) Alan gittikçe küçülür
E) Teğet doğrusuna dönüşür

DRV 16)

Aşağıda her noktada türevlenebilir bir <u>f fonksiyonunun türevinin (f'nün)</u> grafiği verilmiştir.



Yukarıdaki verilere uygun olarak alınacak <u>her f fonksiyonu</u> için **aşağıdakilerden hangisi <u>kesinlikle doğrudur?</u>**
A) $-2 < x < -1$ aralığında artandır
B) $0 < x < 3$ aralığında azalandır
C) $x = 1$ de bir yerel maksimumu vardır
D) $x = -1$ de bir yerel maksimumu vardır
E) $x = -3$ de bir yerel maksimumu vardır

APPENDIX N

THE SIMPLIS SYNTAX FOR THE CFA OF THE PREREQUISITE MODEL

Confirmatory Factor Analysis of the Prerequisite Model

```
CFA Prerequisite
 Raw Data from file 'C:\Users\user\Desktop\2\LAST.psf'
 Latent Variables  PRET PCOMP PANLYS PKU
 Relationships
 Path Diagram
 PRE2  PRE7 PRE9 PRE17 PRE10= PANLYS
 PRE3 PRE4 PRE16= PCOMP
 PRE5 PRE6 PRE12= PKU
 PRE8 PRE13 PRE15 PRE18 = PRET
 Number of Decimals = 3
 Path Diagram
 Admissibility Check = Off
 Iterations = 5000
 Print Residuals
 End of Problem
```

APPENDIX O

SUMMARY STATISTICS FOR THE CFA MODEL OF THE PREREQUISITE TEST

SUMMARY STATISTICS OF FITTED, STANDARDIZED RESIDUALS, STEAM-LEAF AND Q PLOTS OF RESIDUALS FOR CFA OF THE PREREQUISITE TEST

Summary Statistics for Fitted Residuals

```
 Smallest Fitted Residual =   -0.063
   Median Fitted Residual =    0.003
  Largest Fitted Residual =    0.138
```

Stemleaf Plot

```
 - 6|3
 - 5|
 - 4|
 - 3|0
 - 2|53220
 - 1|755222200
 - 0|977765444332210000000000000000000000
   0|11122223344455555666667888899999
   1|001234456677888889
   2|0456778
   3|0359
   4|05
   5|138
   6|
   7|
   8|
   9|
  10|
  11|
  12|0
  13|8
```

Summary Statistics for Standardized Residuals

```
 Smallest Standardized Residual =  -12.099
   Median Standardized Residual =    1.076
  Largest Standardized Residual =    9.849
```

Stemleaf Plot

```
-12|1
-11|
-10|7
- 9|
- 8|
- 7|
- 6|95
- 5|7
- 4|
- 3|7621
- 2|652
- 1|99655444220
- 0|98754421000000000000000000
  0|112348899
  1|011112233444445566788999
  2|0001233677889
  3|111233677
  4|46
  5|02458
  6|49
  7|23
  8|117
  9|8
```

APPENDIX P

GOODNES-OF-FIT CRITERIA FOR THE PREREQUISITE MODEL

Fit Index	Criterion	Value
Chi-Square (χ^2)	Non-significant	251.816 (p<.0000)
Normed Chi-Square (NC)	NC< 5	3,31
Goodness of Fit Index (GFI)	GFI> 0.90	0.980
Adjusted Goodness of Fit Index (AGFI)	AGFI> 0.90	0.969
Root Mean Square Error of Approximation (RMSEA)	0.05 < RMSEA < 0.08 (moderate fit) RMSEA < 0.05 (good fit)	0.0373
Root Mean Square Residual (RMR)	RMR < 0.05	0.0167
Root Mean Square Residual (SRMR)	S-RMR < 0.05	0.0306
Parsimony Goodness of Fit Index (PGFI)	Higher values	0.621
Parsimony Normed Fit Index (PNFI)	Higher values	0.711
Normed Fit Index (NFI)	NFI> 0.90	0.983
Non-Normed Fit Index (NNFI)	NNFI> 0.90	0.983
Comparative Fit Index (CFI)	CFI> 0.90	0.988
Incremental Fit Index (IFI)	IFI> 0.90	0.988
Relative Fit Index (RFI)	RFI> 0.90	0.976

APPENDIX Q

THE SIMPLIS SYNTAX FOR THE CFA OF THE DERIVATIVE MODEL

Confirmatory Factor Analysis of the Derivative Model

```
CFA Derivative
 Raw Data from file 'C:\Users\user\Desktop\2\LAST.psf'
 Latent Variables  DRET DCOMP DANLYS DKU
 Relationships
 DRV1 DRV6 DRV16= DKU
 DRV2 DRV8 DRV3 = DANLYS
 DRV4 DRV14 DRV15= DRET
 DRV9 DRV10 DRV11 DRV13= DCOMP
 Number of Decimals = 3
 Path Diagram
 Admissibility Check = Off
 Iterations = 5000
 Print Residuals
 End of Problem
```

APPENDIX R

SUMMARY STATISTICS FOR THE CFA MODEL OF THE DERIVATIVE TEST

SUMMARY STATISTICS OF FITTED, STANDARDIZED RESIDUALS, STEAM-LEAF AND Q PLOTS OF RESIDUALS FOR CFA OF THE DERIVATIVE TEST

Summary Statistics for Fitted Residuals

```
Smallest Fitted Residual =   -0.040
  Median Fitted Residual =    0.000
 Largest Fitted Residual =    0.055
Stemleaf Plot

- 4|0
- 3|
- 2|874
- 1|73211
- 0|9999877666555444432211111100000000000000000
  0|1111112222444444555666777 8999
  1|234557
  2|234
  3|
  4|
  5|5
```

Summary Statistics for Standardized Residuals

```
Smallest Standardized Residual =   -7.269
  Median Standardized Residual =    0.000
 Largest Standardized Residual =   11.575

Stemleaf Plot
- 6|3
- 4|
- 2|74985542111
- 0|855554221111000087763331100000000000000
  0|1122366778889901133367789
  2|012457888936
  4|0
  6|
  8|
 10|06
```

APPENDIX S

GOODNES-OF-FIT CRITERIA FOR THE DERIVATVE MODEL

Fit Index	Criterion	Value
Chi-Square (χ^2)	Non-significant	189.559 (p<.0000)
Normed Chi-Square (NC)	NC< 5	3,268
Goodness of Fit Index (GFI)	GFI> 0.90	0.983
Adjusted Goodness of Fit Index (AGFI)	AGFI> 0.90	0.973
Root Mean Square Error of Approximation (RMSEA)	0.05 < RMSEA < 0.08 (moderate fit) RMSEA < 0.05 (good fit)	0.0367
Root Mean Square Residual (RMR)	RMR < 0.05	0.0114
Root Mean Square Residual (SRMR)	S-RMR < 0.05	0.0330
Parsimony Goodness of Fit Index (PGFI)	Higher values	0.626
Parsimony Normed Fit Index (PNFI)	Higher values	0.726
Normed Fit Index (NFI)	NFI> 0.90	0.976
Non-Normed Fit Index (NNFI)	NNFI> 0.90	0.978
Comparative Fit Index (CFI)	CFI> 0.90	0.983
Incremental Fit Index (IFI)	IFI> 0.90	0.983
Relative Fit Index (RFI)	RFI> 0.90	0.968

APPENDIX T

THE SIMPLIS SYNTAX FOR THE CFA OF THE DERIVATIVE MODEL

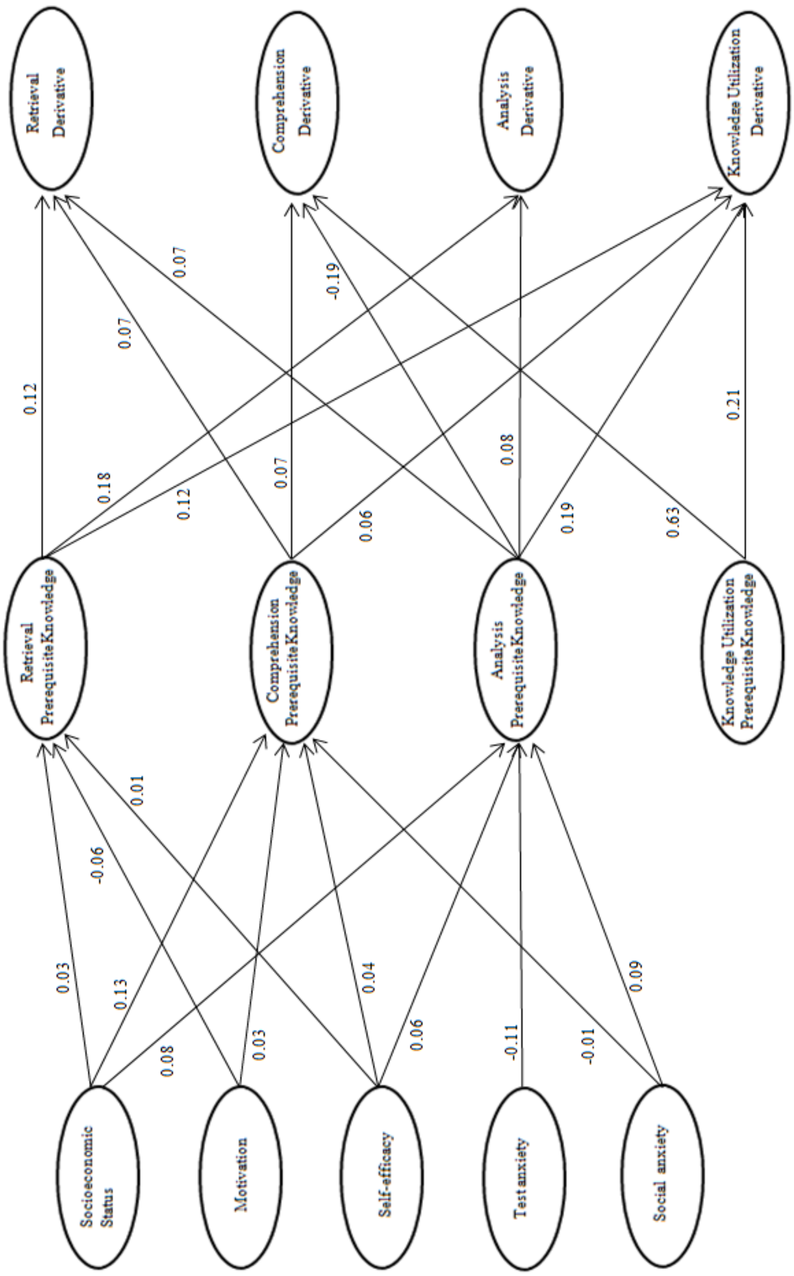
```
Confirmatory Factor Analysis of the Derivative  Model

Drvmodel
Raw Data from file 'C:\Users\Fulya\Desktop\2\LAST.psf'
Latent Variables  SES SELF MOTIV SANX TANX PRET PCOMP PANLYS PKU
DRET DCOMP DANLYS DKU
Relationships
HOMEPC EVKITAP  INTERNET SELFPC MOTHERED FATHERED = SES
MOTIV1  MOTIV2 MOTIV3 MOTIV4 MOTIV5 MOTIV10= MOTIV
ANX1 ANX2 ANX3 ANX5 ANX6 ANX7 ANX8 ANX9 ANX10 ANX11 ANX12 ANX13
ANX14 ANX15 ANX4= SANX
ANX16 ANX17 ANX18 ANX19 ANX21 ANX22 ANX23 ANX25 ANX27 ANX28 ANX29
ANX30 = TANX
SELFEF1 SELFEF2 SELFEF3 SELFEF4 SELFEF5 SELFEF6 SELFEF7 SELFEF8 = SELF
PRE2  PRE7 PRE9 PRE17 PRE10 = PANLYS
PRE3 PRE4 PRE16= PCOMP
PRE5 PRE6 PRE12= PKU
PRE8 PRE13 PRE15 PRE18 = PRET
DRV1 DRV6 DRV16= DKU
DRV3 DRV2 DRV8 = DANLYS
DRV4 DRV14 DRV15= DRET
DRV9 DRV10 DRV11 DRV13= DCOMP
PRET = MOTIV SES SELF
PCOMP =MOTIV SES SANX SELF
PANLYS = SES SANX TANX SELF
DRET = PRET PCOMP PANLYS MOTIV SES SANX TANX SELF
DCOMP = PCOMP PANLYS SANX TANX SELF DRET
DANLYS = PRET PANLYS MOTIV SES TANX SELF DRET
DKU =  PRET PCOMP PANLYS PKU SES DRET DANLYS
Number of Decimals = 3
Path Diagram
Admissibility Check = Off
Iterations = 5000
Print Residuals
Let the Errors of PRE7 and PRE2 Correlate
Let the Errors of PRE9  and PRE7 Correlate
Let the Errors of PRE10  and PRE2 Correlate
Let the Errors of DRV11and DRV8 Correlate
Let the Errors of INTERNET and HOMEPC Correlate e
Let the Errors of FATHERED  and MOTHERED  Correlate
```

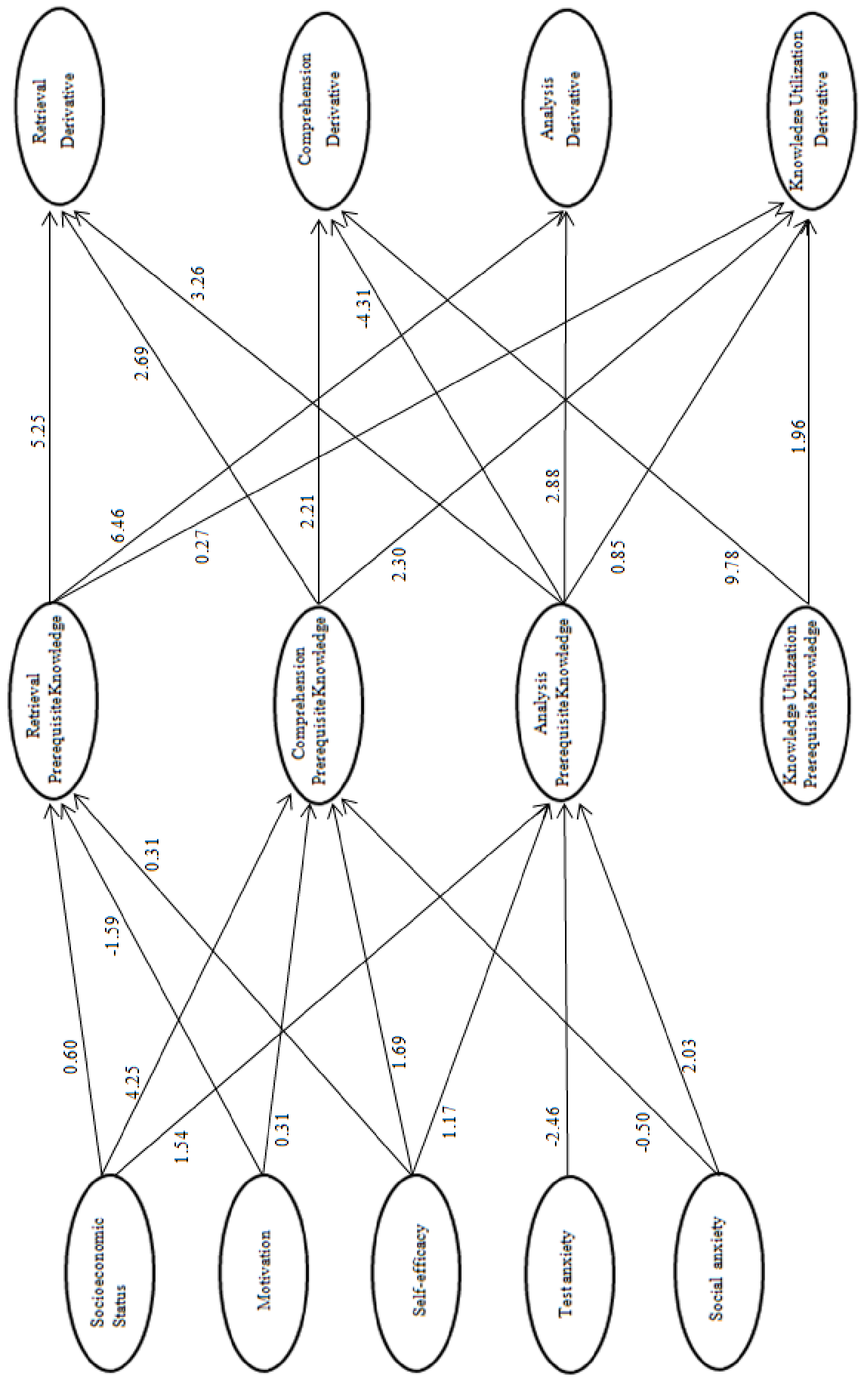
Let the Errors of ANX2 and ANX1 Correlate
Let the Errors of ANX3 and ANX2 Correlate
Let the Errors of ANX4 and ANX3 Correlate
Let the Errors of ANX5 and ANX4 Correlate
Let the Errors of ANX7 and ANX6 Correlate
Let the Errors of ANX13 and ANX10 Correlate
Let the Errors of ANX14 and ANX13 Correlate
Let the Errors of ANX15 and ANX10 Correlate
Let the Errors of ANX17 and ANX16 Correlate
Let the Errors of ANX18 and ANX16 Correlate
Let the Errors of ANX19 and ANX18 Correlate
Let the Errors of ANX21 and ANX16 Correlate
Let the Errors of ANX22 and ANX21 Correlate
Let the Errors of ANX23 and ANX18 Correlate
Let the Errors of ANX25 and ANX23 Correlate
Let the Errors of ANX29 and ANX16 Correlate
Let the Errors of ANX30 and ANX29 Correlate
Let the Errors of SELFEF2 and SELFEF Correlate
Let the Errors of SELFPC and INTERNET Correlate
Let the Errors of ANX5 and ANX3 Correlate

End of Problem

APPENDIX U

LISREL ESTIMATES OF PARAMETERS FOR THE DERIVATIVE MODEL





Retrieval Derivative
Comprehension Derivative
Analysis Derivative
Knowledge Utilization Derivative
5.25
2.69
3.26
-4.31
1.96
6.46
0.27
2.21
2.30
2.88
0.85
9.78
Retrieval Prerequisite Knowledge
Comprehension Prerequisite Knowledge
Analysis Prerequisite Knowledge
Knowledge Utilization Prerequisite Knowledge
0.31
-1.59
0.60
4.25
1.54
0.31
1.69
1.17
-2.46
-0.50
2.03
Socioeconomic Status
Motivation
Self-efficacy
Test anxiety
Social anxiety

APPENDIX V

SUMMARY STATISTICS FOR THE DERIVATIVE MODEL

SUMMARY STATISTICS OF FITTED, STANDARDIZED RESIDUALS, STEAM-LEAF AND Q PLOTS OF RESIDUALS FOR DERIVATIVE MODEL

```
 Summary Statistics for Fitted Residuals
 Smallest Fitted Residual =   -0.197
 Median Fitted Residual =    0.001
 Largest Fitted Residual =    0.263

 Stemleaf Plot
 -18|7
 -16|
 -14|732097
 -12|85308541
 -10|6432110076
 - 8|99986653111100998776666443222210
 - 6|988777666555544433211099888877666544444333211111
 -
4|99999998888877777777666655555555544444444433333333222222111000000099999999+
53
 -
2|99999998888887777777777666666666666666655555555544444444443333333333333322+
93
 -
0|99999999999999999999999999888888888888888888888888888887777777777777777777+
96

0|1111111111111111111111111111111111111111111111111111111111111111111111111+
91

2|00000000000000000000111111111111111122222222222222222222333333333333333333+
96

4|00000001111111122222222233344455555556666666666778888890000122222333333333+
23
   6|000000111122222345555666778880000222334466667799
   8|0123445566780011268
  10|00002335688911112334577 8
  12|0001124491688
  14|0235159
  16|036
```

18|2723
20|08245
22|34
24|4
26|3

Summary Statistics for Standardized Residuals
Smallest Standardized Residual =   -8.165
Median Standardized Residual =   0.073
Largest Standardized Residual =   12.875

Stemleaf Plot
- 8|2
- 7|3
- 6|975431000
- 5|8877665554443332110000
- 4|99887766666666555544433332110000000000
-
3|9888888888777777777666666555555554444444444443333333333322222222221111+
18
-
2|9999999999888888888888888888888877777777777666666666666666666666555555555555+
47
-
1|99999999999999999999999999999999999888888888888888888888777777777777777777+
96
-
0|9999999999999999999999999999999999999999999988888888888888888888888888888+
93

0|111111111111111111111111111111111111111111111111111111111111111111111222+
96

1|0000000000000000000000000000000000000000000000000000000011111111111+
95

2|0000000000000000000000000000111111111111111111111111111111112222222222+
70

3|000000000000111111111111111122222222222222223333333333444444445555556677+
11
4|0001111122223333333344444567777788888889999
5|0011223345677888999999
6|00001112256788888888899999
7|000111444567
8|00000025566799
9|1
10|467
11|
12|9

Largest Negative Standardized Residuals
Residual for PRE2 and PRE2 -6.490
Residual for PRE9 and PRE2 -2.624
Residual for PRE9 and PRE7 -2.843
Residual for PRE13 and PRE7 -3.138
Residual for PRE13 and PRE8 -5.999
Residual for PRE18 and PRE15 -5.313
Residual for DRV1 and PRE7 -2.794
Residual for DRV3 and PRE10 -2.883
Residual for DRV3 and PRE13 -3.567
Residual for DRV9 and PRE15 -3.126
Residual for DRV11 and PRE15 -2.654
Residual for DRV14 and PRE13 -4.036
Residual for DRV15 and DRV4 -3.356
Residual for INTERNET and PRE16 -2.589
Residual for SELFPC and PRE16 -2.921
Residual for SELFPC and DRV4 -2.784
Residual for MOTHERED and PRE2 -3.539
Residual for MOTHERED and PRE10 -3.286
Residual for MOTHERED and PRE16 -3.297
Residual for MOTHERED and DRV1 -3.191
Residual for MOTHERED and MOTHERED -2.701
Residual for FATHERED and PRE16 -3.059
Residual for MOTIV2 and DRV3 -2.966
Residual for MOTIV4 and MOTIV1 -4.999
Residual for MOTIV5 and DRV16 -2.865
Residual for MOTIV5 and MOTIV2 -3.344
Residual for MOTIV10 and EVKITAP -2.925
Residual for MOTIV10 and MOTHERED -3.126
Residual for MOTIV10 and FATHERED -4.026
Residual for MOTIV10 and MOTIV2 -4.262
Residual for ANX2 and FATHERED -3.252
Residual for ANX8 and PRE2 -2.643
Residual for ANX8 and PRE7 -3.370
Residual for ANX8 and PRE8 -2.820
Residual for ANX8 and PRE9 -3.174
Residual for ANX8 and PRE10 -3.358
Residual for ANX8 and PRE13 -2.831
Residual for ANX8 and MOTHERED -2.618
Residual for ANX8 and FATHERED -3.450
Residual for ANX8 and MOTIV4 -2.921
Residual for ANX8 and ANX1 -2.799
Residual for ANX9 and ANX2 -2.697
Residual for ANX10 and MOTIV2 -2.750
Residual for ANX10 and MOTIV3 -3.168
Residual for ANX10 and ANX3 -3.888
Residual for ANX10 and ANX4 -5.680
Residual for ANX10 and ANX5 -3.652
Residual for ANX11 and PRE2 -3.013

Residual for	ANX11 and	PRE7	-4.069
Residual for	ANX11 and	PRE8	-3.994
Residual for	ANX11 and	PRE9	-4.506
Residual for	ANX11 and	PRE10	-4.780
Residual for	ANX11 and	DRV8	-3.002
Residual for	ANX11 and	SELFPC	-3.251
Residual for	ANX11 and	ANX1	-3.745
Residual for	ANX11 and	ANX2	-4.424
Residual for	ANX11 and	ANX3	-5.594
Residual for	ANX11 and	ANX4	-2.716
Residual for	ANX12 and	DRV14	-2.750
Residual for	ANX12 and	MOTIV4	-3.632
Residual for	ANX12 and	ANX7	-3.639
Residual for	ANX12 and	ANX8	-6.113
Residual for	ANX13 and	PRE9	-3.662
Residual for	ANX13 and	PRE10	-3.384
Residual for	ANX13 and	PRE17	-3.197
Residual for	ANX13 and	MOTIV1	-2.612
Residual for	ANX13 and	MOTIV2	-4.877
Residual for	ANX13 and	MOTIV3	-4.892
Residual for	ANX13 and	MOTIV4	-3.252
Residual for	ANX13 and	MOTIV5	-3.662
Residual for	ANX13 and	ANX1	-5.376
Residual for	ANX13 and	ANX3	-4.635
Residual for	ANX13 and	ANX4	-5.831
Residual for	ANX13 and	ANX5	-3.364
Residual for	ANX14 and	ANX1	-4.135
Residual for	ANX14 and	ANX2	-2.880
Residual for	ANX14 and	ANX4	-3.082
Residual for	ANX14 and	ANX12	-2.797
Residual for	ANX15 and	MOTIV3	-3.147
Residual for	ANX15 and	MOTIV4	-3.786
Residual for	ANX15 and	ANX4	-3.266
Residual for	ANX15 and	ANX6	-2.631
Residual for	ANX16 and	PRE9	-3.627
Residual for	ANX16 and	PRE10	-3.418
Residual for	ANX16 and	MOTIV3	-5.167
Residual for	ANX16 and	ANX1	-3.768
Residual for	ANX16 and	ANX3	-4.626
Residual for	ANX16 and	ANX4	-3.771
Residual for	ANX17 and	PRE9	-2.601
Residual for	ANX17 and	MOTIV3	-5.006
Residual for	ANX17 and	ANX1	-6.884
Residual for	ANX17 and	ANX2	-4.283
Residual for	ANX17 and	ANX3	-8.165
Residual for	ANX17 and	ANX4	-7.348
Residual for	ANX17 and	ANX5	-5.595
Residual for	ANX17 and	ANX9	-3.059
Residual for	ANX17 and	ANX12	-4.334
Residual for	ANX18 and	PRE8	-2.576

Residual for ANX18 and DRV13 -2.644
Residual for ANX18 and DRV14 -2.733
Residual for ANX18 and HOMEPC -2.713
Residual for ANX18 and MOTIV3 -3.970
Residual for ANX18 and MOTIV10 -3.541
Residual for ANX18 and ANX1 -5.475
Residual for ANX18 and ANX2 -3.135
Residual for ANX18 and ANX3 -6.665
Residual for ANX18 and ANX4 -5.833
Residual for ANX18 and ANX5 -4.712
Residual for ANX18 and ANX9 -3.037
Residual for ANX18 and ANX12 -2.978
Residual for ANX19 and HOMEPC -3.514
Residual for ANX19 and EVKITAP -2.813
Residual for ANX19 and ANX1 -4.583
Residual for ANX19 and ANX3 -3.844
Residual for ANX19 and ANX4 -3.604
Residual for ANX19 and ANX12 -2.828
Residual for ANX21 and PRE8 -3.615
Residual for ANX21 and PRE9 -2.583
Residual for ANX21 and HOMEPC -4.187
Residual for ANX21 and MOTIV3 -3.420
Residual for ANX21 and ANX1 -4.590
Residual for ANX21 and ANX3 -5.951
Residual for ANX21 and ANX4 -4.636
Residual for ANX22 and HOMEPC -3.193
Residual for ANX25 and PRE8 -2.858
Residual for ANX25 and SELFPC -3.048
Residual for ANX27 and PRE8 -3.070
Residual for ANX27 and DRV8 -3.051
Residual for ANX27 and HOMEPC -2.595
Residual for ANX27 and INTERNET -2.759
Residual for ANX27 and ANX1 -5.295
Residual for ANX27 and ANX3 -4.438
Residual for ANX27 and ANX4 -4.040
Residual for ANX27 and ANX5 -3.177
Residual for ANX27 and ANX9 -4.019
Residual for ANX27 and ANX12 -3.277
Residual for ANX27 and ANX16 -3.210
Residual for ANX27 and ANX21 -6.433
Residual for ANX27 and ANX22 -3.729
Residual for ANX27 and ANX25 -4.009
Residual for ANX28 and ANX1 -5.422
Residual for ANX28 and ANX3 -4.404
Residual for ANX28 and ANX4 -3.345
Residual for ANX28 and ANX5 -2.807
Residual for ANX28 and ANX9 -2.629
Residual for ANX28 and ANX12 -3.904
Residual for ANX28 and ANX23 -3.428
Residual for ANX28 and ANX25 -5.515

Residual for ANX29 and ANX1 -6.028
Residual for ANX29 and ANX2 -2.966
Residual for ANX29 and ANX3 -5.269
Residual for ANX29 and ANX4 -3.826
Residual for ANX29 and ANX5 -2.758
Residual for ANX29 and ANX9 -3.192
Residual for ANX29 and ANX12 -3.988
Residual for ANX29 and ANX19 -4.489
Residual for ANX29 and ANX22 -2.796
Residual for ANX29 and ANX23 -3.246
Residual for ANX29 and ANX25 -6.278
Residual for ANX30 and HOMEPC -2.682
Residual for ANX30 and SELFPC -2.613
Residual for ANX30 and MOTIV3 -2.677
Residual for ANX30 and ANX1 -5.371
Residual for ANX30 and ANX3 -4.950
Residual for ANX30 and ANX4 -3.981
Residual for ANX30 and ANX12 -3.373
Residual for ANX30 and ANX19 -3.382
Residual for ANX30 and ANX22 -2.690
Residual for ANX30 and ANX23 -2.838
Residual for ANX30 and ANX25 -4.594
Residual for SELFEF2 and DRV15 -2.755
Residual for SELFEF2 and ANX1 -3.513
Residual for SELFEF2 and ANX3 -2.917
Residual for SELFEF2 and ANX4 -3.451
Residual for SELFEF2 and ANX5 -3.670
Residual for SELFEF3 and PRE17 -3.658
Residual for SELFEF3 and DRV15 -4.482
Residual for SELFEF3 and ANX3 -2.927
Residual for SELFEF3 and ANX4 -2.848
Residual for SELFEF3 and ANX5 -2.902
Residual for SELFEF4 and PRE17 -5.125
Residual for SELFEF4 and DRV9 -3.789
Residual for SELFEF4 and FATHERED -3.406
Residual for SELFEF4 and ANX17 -3.787
Residual for SELFEF5 and PRE3 -2.792
Residual for SELFEF5 and PRE17 -4.720
Residual for SELFEF5 and DRV9 -3.066
Residual for SELFEF5 and SELFEF1 -5.115
Residual for SELFEF6 and PRE17 -4.840
Residual for SELFEF6 and DRV9 -3.523
Residual for SELFEF6 and ANX9 -2.620
Residual for SELFEF6 and ANX16 -3.285
Residual for SELFEF6 and ANX17 -3.788
Residual for SELFEF6 and ANX18 -2.591
Residual for SELFEF6 and SELFEF1 -3.292
Residual for SELFEF6 and SELFEF3 -5.707
Residual for SELFEF7 and DRV9 -2.650
Residual for SELFEF7 and FATHERED -2.844

Residual for	SELFEF7 and	MOTIV1	-3.062
Residual for	SELFEF7 and	MOTIV2	-3.699
Residual for	SELFEF7 and	MOTIV4	-5.538
Residual for	SELFEF7 and	ANX16	-3.128
Residual for	SELFEF7 and	ANX17	-3.274
Residual for	SELFEF7 and	SELFEF3	-4.475
Residual for	SELFEF7 and	SELFEF5	-4.599
Residual for	SELFEF8 and	MOTIV2	-3.230
Residual for	SELFEF8 and	MOTIV4	-3.041
Residual for	SELFEF8 and	ANX16	-2.743
Residual for	SELFEF8 and	ANX17	-3.396
Residual for	SELFEF8 and	SELFEF4	-3.716
Residual for	SELFEF8 and	SELFEF5	-3.774
Residual for	PRE12 and	PRE7	-3.498
Residual for	PRE12 and	PRE10	-3.954
Residual for	PRE12 and	MOTIV2	-4.601
Residual for	PRE12 and	ANX8	-4.328
Residual for	PRE12 and	ANX27	-3.052

Largest Positive Standardized Residuals

Residual for	PRE4 and	PRE3	3.265
Residual for	PRE4 and	PRE4	3.269
Residual for	PRE7 and	PRE7	2.843
Residual for	PRE8 and	PRE2	5.150
Residual for	PRE8 and	PRE7	3.234
Residual for	PRE9 and	PRE8	7.996
Residual for	PRE10 and	PRE2	6.490
Residual for	PRE10 and	PRE7	5.092
Residual for	PRE10 and	PRE8	7.974
Residual for	PRE15 and	PRE8	6.956
Residual for	PRE15 and	PRE13	3.527
Residual for	PRE16 and	PRE4	2.636
Residual for	PRE16 and	PRE8	2.986
Residual for	PRE16 and	PRE9	3.964
Residual for	PRE16 and	PRE10	2.743
Residual for	PRE17 and	PRE8	5.523
Residual for	PRE17 and	PRE13	2.948
Residual for	PRE17 and	PRE15	3.065
Residual for	PRE17 and	PRE16	3.281
Residual for	PRE18 and	PRE9	3.228
Residual for	PRE18 and	PRE13	5.906
Residual for	PRE18 and	PRE16	3.096
Residual for	PRE18 and	PRE17	5.778
Residual for	DRV1 and	DRV1	5.893
Residual for	DRV2 and	PRE4	4.819
Residual for	DRV2 and	PRE13	3.524
Residual for	DRV2 and	PRE17	2.847
Residual for	DRV2 and	DRV1	3.219
Residual for	DRV3 and	PRE9	2.613
Residual for	DRV3 and	PRE17	4.863
Residual for	DRV4 and	PRE4	5.808

Residual for DRV4 and PRE16 2.979
Residual for DRV4 and PRE17 3.028
Residual for DRV4 and DRV1 4.024
Residual for DRV6 and PRE17 2.707
Residual for DRV6 and DRV2 2.802
Residual for DRV6 and DRV4 5.315
Residual for DRV6 and DRV6 5.893
Residual for DRV8 and DRV3 3.797
Residual for DRV8 and DRV8 3.866
Residual for DRV9 and PRE3 3.108
Residual for DRV9 and DRV1 3.688
Residual for DRV9 and DRV9 8.020
Residual for DRV10 and PRE17 4.401
Residual for DRV10 and DRV2 3.229
Residual for DRV10 and DRV3 4.869
Residual for DRV10 and DRV8 4.551
Residual for DRV10 and DRV10 8.020
Residual for DRV11 and DRV1 3.195
Residual for DRV11 and DRV3 2.824
Residual for DRV11 and DRV8 3.070
Residual for DRV11 and DRV9 3.234
Residual for DRV11 and DRV11 8.020
Residual for DRV13 and PRE9 3.292
Residual for DRV13 and PRE16 3.026
Residual for DRV13 and DRV13 8.020
Residual for DRV15 and PRE4 3.322
Residual for DRV15 and PRE15 3.458
Residual for DRV15 and PRE17 6.578
Residual for DRV15 and PRE18 3.053
Residual for DRV15 and DRV2 2.643
Residual for DRV15 and DRV3 3.414
Residual for DRV15 and DRV6 2.596
Residual for DRV15 and DRV13 2.586
Residual for DRV15 and DRV14 2.920
Residual for DRV16 and PRE16 2.816
Residual for DRV16 and DRV6 5.213
Residual for DRV16 and DRV16 5.893
Residual for FATHERED and DRV16 4.721
Residual for FATHERED and EVKITAP 2.619
Residual for FATHERED and INTERNET 2.678
Residual for FATHERED and MOTHERED 2.701
Residual for FATHERED and FATHERED 2.701
Residual for MOTIV1 and HOMEPC 4.301
Residual for MOTIV3 and PRE16 3.197
Residual for MOTIV4 and DRV9 3.051
Residual for MOTIV4 and DRV11 3.328
Residual for MOTIV4 and MOTIV2 5.691
Residual for MOTIV10 and PRE16 3.190
Residual for MOTIV10 and MOTIV5 4.668
Residual for ANX1 and PRE2 2.828

Residual for	ANX1 and	PRE10	2.744
Residual for	ANX1 and	HOMEPC	2.901
Residual for	ANX1 and	MOTIV1	4.137
Residual for	ANX1 and	MOTIV10	7.526
Residual for	ANX2 and	DRV10	3.127
Residual for	ANX2 and	MOTIV10	7.663
Residual for	ANX3 and	PRE2	2.812
Residual for	ANX3 and	PRE10	3.439
Residual for	ANX3 and	MOTIV10	6.036
Residual for	ANX3 and	ANX1	7.369
Residual for	ANX3 and	ANX2	7.364
Residual for	ANX3 and	ANX3	9.150
Residual for	ANX4 and	DRV1	2.692
Residual for	ANX4 and	MOTIV10	6.157
Residual for	ANX4 and	ANX1	7.086
Residual for	ANX4 and	ANX2	6.925
Residual for	ANX4 and	ANX3	8.695
Residual for	ANX5 and	PRE15	2.695
Residual for	ANX5 and	DRV4	2.629
Residual for	ANX5 and	MOTIV10	5.745
Residual for	ANX6 and	PRE3	2.618
Residual for	ANX6 and	MOTIV10	4.403
Residual for	ANX6 and	ANX5	3.777
Residual for	ANX7 and	MOTIV10	4.248
Residual for	ANX8 and	DRV4	2.691
Residual for	ANX8 and	ANX6	3.484
Residual for	ANX8 and	ANX7	8.917
Residual for	ANX9 and	PRE16	3.230
Residual for	ANX9 and	DRV4	2.595
Residual for	ANX9 and	DRV10	2.786
Residual for	ANX9 and	MOTIV10	5.019
Residual for	ANX9 and	ANX7	3.365
Residual for	ANX9 and	ANX8	3.896
Residual for	ANX10 and	MOTIV10	2.742
Residual for	ANX11 and	MOTIV10	3.293
Residual for	ANX11 and	ANX10	4.267
Residual for	ANX12 and	INTERNET	3.075
Residual for	ANX12 and	MOTIV10	4.650
Residual for	ANX12 and	ANX1	6.970
Residual for	ANX12 and	ANX3	4.281
Residual for	ANX12 and	ANX4	2.731
Residual for	ANX12 and	ANX11	2.577
Residual for	ANX13 and	ANX10	6.845
Residual for	ANX13 and	ANX11	3.022
Residual for	ANX13 and	ANX13	6.845
Residual for	ANX14 and	ANX9	3.484
Residual for	ANX14 and	ANX10	6.845
Residual for	ANX14 and	ANX13	6.845
Residual for	ANX15 and	ANX2	3.145
Residual for	ANX15 and	ANX10	6.845

Residual for	ANX15 and	ANX13	6.845
Residual for	ANX15 and	ANX14	6.845
Residual for	ANX15 and	ANX15	6.845
Residual for	ANX16 and	MOTHERED	3.355
Residual for	ANX16 and	ANX10	3.376
Residual for	ANX16 and	ANX11	5.561
Residual for	ANX16 and	ANX13	10.610
Residual for	ANX16 and	ANX14	5.785
Residual for	ANX16 and	ANX15	4.963
Residual for	ANX17 and	MOTHERED	3.192
Residual for	ANX17 and	ANX11	4.730
Residual for	ANX17 and	ANX13	8.532
Residual for	ANX18 and	ANX11	4.421
Residual for	ANX18 and	ANX13	8.595
Residual for	ANX18 and	ANX14	2.814
Residual for	ANX19 and	ANX11	6.095
Residual for	ANX19 and	ANX13	7.020
Residual for	ANX19 and	ANX14	4.774
Residual for	ANX21 and	ANX11	5.352
Residual for	ANX21 and	ANX13	7.432
Residual for	ANX21 and	ANX14	3.854
Residual for	ANX21 and	ANX15	2.874
Residual for	ANX21 and	ANX19	4.113
Residual for	ANX22 and	DRV15	2.688
Residual for	ANX22 and	MOTIV2	4.071
Residual for	ANX22 and	MOTIV10	3.872
Residual for	ANX22 and	ANX8	2.633
Residual for	ANX22 and	ANX9	3.672
Residual for	ANX22 and	ANX11	6.048
Residual for	ANX22 and	ANX13	3.226
Residual for	ANX22 and	ANX14	2.938
Residual for	ANX22 and	ANX15	3.786
Residual for	ANX22 and	ANX19	2.987
Residual for	ANX22 and	ANX21	2.872
Residual for	ANX22 and	ANX22	2.693
Residual for	ANX23 and	ANX10	2.621
Residual for	ANX23 and	ANX11	6.681
Residual for	ANX23 and	ANX13	5.944
Residual for	ANX23 and	ANX14	4.910
Residual for	ANX23 and	ANX15	4.146
Residual for	ANX23 and	ANX19	4.160
Residual for	ANX23 and	ANX21	3.146
Residual for	ANX23 and	ANX22	4.092
Residual for	ANX23 and	ANX23	3.166
Residual for	ANX25 and	ANX5	3.356
Residual for	ANX25 and	ANX6	3.194
Residual for	ANX25 and	ANX7	3.779
Residual for	ANX25 and	ANX8	3.338
Residual for	ANX25 and	ANX9	4.324
Residual for	ANX25 and	ANX10	6.033

Residual for ANX25 and ANX11 8.487
Residual for ANX25 and ANX12 4.287
Residual for ANX25 and ANX13 8.949
Residual for ANX25 and ANX14 8.643
Residual for ANX25 and ANX15 7.057
Residual for ANX25 and ANX17 3.435
Residual for ANX25 and ANX19 4.256
Residual for ANX25 and ANX21 2.753
Residual for ANX25 and ANX22 3.392
Residual for ANX25 and ANX23 2.846
Residual for ANX27 and ANX13 3.667
Residual for ANX28 and EVKITAP 2.897
Residual for ANX28 and MOTHERED 4.784
Residual for ANX28 and ANX11 4.335
Residual for ANX28 and ANX13 6.088
Residual for ANX28 and ANX14 3.140
Residual for ANX28 and ANX27 10.423
Residual for ANX29 and MOTHERED 4.196
Residual for ANX29 and ANX11 2.950
Residual for ANX29 and ANX13 5.236
Residual for ANX29 and ANX27 12.875
Residual for ANX30 and PRE7 2.584
Residual for ANX30 and ANX11 3.705
Residual for ANX30 and ANX13 7.060
Residual for ANX30 and ANX14 2.909
Residual for ANX30 and ANX27 10.707
Residual for SELFEF1 and ANX13 3.666
Residual for SELFEF1 and ANX30 2.790
Residual for SELFEF2 and ANX25 2.832
Residual for SELFEF2 and SELFEF1 6.853
Residual for SELFEF2 and SELFEF2 6.853
Residual for SELFEF3 and ANX28 2.674
Residual for SELFEF3 and ANX30 3.328
Residual for SELFEF3 and SELFEF1 6.853
Residual for SELFEF3 and SELFEF2 6.853
Residual for SELFEF4 and MOTIV10 2.805
Residual for SELFEF4 and ANX8 3.535
Residual for SELFEF5 and MOTIV2 2.862
Residual for SELFEF5 and ANX8 2.878
Residual for SELFEF5 and SELFEF3 3.636
Residual for SELFEF6 and DRV4 3.093
Residual for SELFEF6 and INTERNET 2.888
Residual for SELFEF6 and ANX8 4.432
Residual for SELFEF6 and SELFEF5 3.136
Residual for SELFEF7 and PRE4 3.076
Residual for SELFEF7 and DRV2 3.022
Residual for SELFEF7 and DRV3 2.895
Residual for SELFEF7 and DRV8 2.937
Residual for SELFEF7 and DRV10 3.019
Residual for SELFEF7 and ANX8 4.774

Residual for SELFEF7 and SELFEF6 4.822
Residual for SELFEF8 and PRE3 2.739
Residual for SELFEF8 and PRE4 2.855
Residual for SELFEF8 and ANX2 2.635
Residual for SELFEF8 and ANX8 4.167
Residual for SELFEF8 and SELFEF1 6.192
Residual for SELFEF8 and SELFEF2 4.906
Residual for SELFEF8 and SELFEF3 5.324
Residual for PRE5 and PRE9 2.864
Residual for PRE5 and ANX11 2.694
Residual for PRE5 and ANX12 3.026
Residual for PRE5 and ANX29 3.118
Residual for PRE6 and PRE2 2.881
Residual for PRE6 and PRE8 3.316
Residual for PRE6 and PRE9 4.459
Residual for PRE6 and PRE10 2.870
Residual for PRE6 and PRE17 2.953
Residual for PRE6 and DRV4 8.198
Residual for PRE6 and DRV14 4.665
Residual for PRE6 and DRV15 6.053
Residual for PRE12 and PRE3 3.084
Residual for PRE12 and PRE8 4.421
Residual for PRE12 and PRE16 2.575
Residual for PRE12 and PRE17 4.839
Residual for PRE12 and DRV2 3.995
Residual for PRE12 and DRV3 3.560
Residual for PRE12 and DRV4 7.574
Residual for PRE12 and DRV8 3.527
Residual for PRE12 and DRV11 3.110
Residual for PRE12 and DRV15 6.045
Residual for PRE12 and HOMEPC 2.915
Residual for PRE12 and FATHERED 2.791
Residual for PRE12 and SELFEF1 2.991
Residual for PRE12 and SELFEF7 3.212
Residual for PRE12 and SELFEF8 2.628

APPENDIX W

THE MEASUREMENT COEFFICIENTS AND ERROR VARIANCES FOR THE DERIVATIVE MODEL

Latent Variables	Observed Variables	λ_Y	ε
Derivative Knowledge Utilization	drv6	0.437	0.0578
	drv16	0.372	0.111
	drv1	0.642	0.346
Derivative Analysis	drv3	0.788	0.293
	drv8	0.244	0.129
	drv2	0.248	0.119
Derivative Comprehension	drv9	0.331	0.137
	drv13	0.264	0.133
	drv10	0.310	0.154
	drv11	0.269	0.169
Derivative Retrieval	drv15	0.331	0.0742
	drv14	0.330	0.104
	drv4	0.253	0.0544

APPENDIX X

SQUARED MULTIPLE CORRELATIONS OF THE OBSERVED VARIABLES

Observed Variable	R^2	Observed Variable	R^2
ANXIETY1	0.52	ANX15	0.39
ANXIETY2	0.54	ANX16	0.27
ANXIETY3	0.51	ANX17	0.27
ANXIETY4	0.48	ANX18	0.20
ANXIETY5	0.74	ANX19	0.33
ANXIETY6	0.43	ANX21	0.48
ANXIETY7	0.37	ANX22	0.55
ANXIETY8	0.62	ANX23	0.39
ANXIETY9	0.45	ANX25	0.31
ANX10	0.46	ANX27	0.37
ANX11	0.49	ANX28	0.59
ANX12	0.65	ANX29	0.58
ANX13	0.22	ANX30	0.57
ANX14	0.33	PRE2	0.39
PRE3	0.77	PRE4	0.51
PRE5	0.62	PRE6	0.15
PRE7	0.51	PRE9	0.57
PRE10	0.81	PRE12	0.32
PRE13	0.80	PRE15	0.61
PRE16	0.05	PRE17	0.09
PRE18	0.63	DRV16	0.55
DRV1	0.54	DRV2	0.48
DRV3	0.83	DRV4	0.54
DRV6	0.77	DRV8	0.45
DRV9	0.29	DRV10	0.20
DRV11	0.17	DRV13	0.13
DRV14	0.51	DRV15	0.60

APPENDIX Y

THE STRUCTURAL REGRESSION EQUATIONS OF THE DERIVATIVE MODEL

PRET = 0.0290*SES + 0.0139*SELF - 0.0639*MOTIV, Errorvar.= 1.517 , R- = 0.210

(0.0481) (0.0445) (0.0400) (0.0947)

0.604 0.313 -1.598 16.020

PCOMP = 0.131*SES + 0.0415*SELF + 0.0321*MOTIV - 0.0139*SANX, Errorvar.= 0.982 , R- = 0.0177

(0.0308) (0.0245) (0.0245) (0.0277) (0.135)

4.250 1.690 1.307 -0.501 7.296

PANLYS = 0.0759*SES + 0.0553*SELF + 0.0974*SANX - 0.107*TANX , Errorvar.= 1.401 , R- = 0.283

(0.0494) (0.0472) (0.0481) (0.0436) (0.0568)
1.535 1.173 2.026 -2.456 12.893

DRET = 0.117*PRET + 0.0709*PCOMP + 0.0712*PANLYS, (0.0222) (0.0263) (0.0218) (0.0394) (0.0312) (0.0311) (0.0362) (0.0329)

5.246 2.694 3.259

DCOMP = 0.0700*PCOMP - 0.190*PANLYS + 0.932*PKU, Errorvar.= 0.298 ,

(0.0316) (0.0440) (0.0953) (0.0876)

2.214 -4.308 9.783 3.4

DANLYS = 0.178*PRET + 0.0766*PANLYS **,** Errorvar.= 1.583

(0.0275) (0.0266) (0.0828)
6.461 2.875

DKU = 0.117*PRET + 0.0557*PCOMP + 0.192*PANLYS + 0.210*PKU, Errorvar.= 0.920

(0.439) (0.0242) (0.227) (0.313) (0.237)

0.267 2.299 0.848 0.671

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WORK EXPERIENCE

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PUBLICATIONS

Kula, F., Oren Vural, D. (2011) Pre-service Mathematics Teachers' Conceptions of Continuity. *The European Conference on Educational Research*, Berlin, Germany (13-16 September 2011, Freie Universität, Berlin, Germany)

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HOBBIES

Cooking, Creative Writing, Classical Music, Drawing, Swimming