A SURVEY OF MATHEMATICAL KNOWLEDGE AND SKILLS IN HIGH SCHOOL NEEDED FOR PROFESSIONS IN SOCIAL SCIENCES

A MASTER'S THESIS

BY

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To Mustafa Kemal Atatürk

A SURVEY OF MATHEMATICAL KNOWLEDGE AND SKILLS IN HIGH SCHOOL NEEDED FOR PROFESSIONS IN SOCIAL SCIENCES

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May 2013

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

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ABSTRACT

A SURVEY OF MATHEMATICAL KNOWLEDGE AND SKILLS IN HIGH SCHOOL NEEDED FOR PROFESSIONS IN SOCIAL SCIENCES

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May 2013

The purpose of this study is to identify the mathematics topics and skills that are important in high school mathematics curriculum for higher education in social science departments such as law, psychology and history, based on scores assigned by staff from university and industry. A survey including five-point Likert type items was used in the present study. Analyses were conducted with respect to departments and institutions. There was a convergence of the perceived importance selected mathematical knowledge and skills for preparation of social science education at university. However, 9^{th} grade mathematics topics are enough to teach all students who prefer to study in a social science in this regard. Also there was no difference among institutions. Some suggestions about high school mathematics curriculum are made in the present study.

Key words: Differentiated curriculum, social sciences, mathematics high school curriculum, and university education.

ÖZET

SOSYAL BİLİMLERDEKİ BÖLÜMLERDE GEREKLİ OLAN LİSE MATEMATİK BİLGİ VE BECERİLERİNİ BELİRLEME ANKETİ

Gülümser Özalp

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Bu çalışmanın amacı, üniversite ve iş hayatında çalışan kişilerce belirlenen sonuçlara bağlı olarak sosyal bilimlerde hukuk, psikoloji ve tarih gibi bölümlerin üniversite eğitimi için lise matematik müfredatında önemli görülen matematik konuları ve becerilerini belirlemektir. Çalışmada beşli Likert ölçeği olan bir anket kullanılmıştır. Analizler bölümlere ve kurumlara göre yapılmıştır. Üniversitedeki sosyal bilimler eğitimine hazırlık için önemli görülen matematik konuları ve becerilerinde katılımcılar ortak görüş belirtmiştir. Hatta 9. sınıf matematik konuları üniversitede sosyal bilimler eğitimi almak isteyen tüm öğrenciler için yeterli görülmüştür. Bunun yanında kurumlar arasında da herhangi bir farklılık yoktur. Çalışmanın sonunda lise matematik müfredatı için bazı önerilere de yer verilmiştir.

Anahtar Kelimeler: Farklılaştırılmış müfredat, sosyal bilimler, lise matematik müfredatı, üniversite eğitimi.

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CHAPTER 1: INTRODUCTION

Introduction

Mathematics is considered as a core school subject throughout in the world. It plays an important role in many parts of real life. In daily life, a person uses mathematics for many reasons such as telling time, counting, paying on, measuring something, or solving problems by using algebraic operations. In addition to daily life, mathematics is a tool which helps people in vocational life. A computer engineer for example, uses complex mathematics knowledge to design a computer hardware system, a sociologist uses mathematics to make inferences from census data, or a scientist uses mathematics to analyze data from a study. Hence, mathematics education serves to meet needs of almost all careers (Cockcroft, 1982; National Research Council Staff & Mathematical Sciences Educational Board, 1998). As a result of changing humans' needs and vocational choices, countries need to adapt mathematics education according to citizens' needs and choices (Baki, 2003).

Turkey introduced an educational reform for elementary education curriculum in 2005, which was based on constructivist approach (Güven & İşcan, 2006). The Ministry of National Education has been studying on a new high school mathematics curriculum by 4+4+4 system. Hence, this study will primarily focus on high school mathematics curriculum, its types, one of the educational curriculum trends called differentiated curriculum, and differentiation of mathematics topics for university and career readiness of social scientists. The aim of this study was to find out which topics and skills should be included in high school curriculum in order to get better readiness for a social science program at university. As provided practical and useful information about mathematics topics in high school for social science students, the results of this study will give an idea to curriculum developers about differentiation curriculum in terms of departments.

Background

Currently, mathematics education indicates the level of development of a country. Mathematics education enables countries to develop their economy, science and technology advancement (Işık, Çiltaş, & Bekdemir, 2008). Accordingly, learning mathematics becomes more important for future of countries. Tatar and Dikici (2008) stated that mathematics education should aim for an environment in which all students can learn mathematics at high levels. However, most students in Turkey have many difficulties in learning mathematical topics (Yenilmez, 2010; Aktaş, Mumcu, & Mumcu, 2012). There are research studies which analyze mathematics topics and students' difficulties in learning mathematics from starting elementary to university.

In Turkey, two researchers tested elementary 7^{th} and 8^{th} grade students by preparing two algebra tests based on Turkish national mathematics curriculum. Although students were from 7^{th} and 8^{th} grades, they had similar difficulties in algebra (Ersoy & Erbaş, 1998). Another study concluded that there was a statistically significant correlation between students' difficulties in mathematics and teaching methods (Dikici &İsleyen, 2004). Students lacked motivation and they found abstract mathematical concepts difficult (Durmuş, 2004a). Similar to previous study, elementary mathematics topics especially 8^{th} grade mathematics topics were difficult to learn because these topics had more abstract content than others (Durmus, 2004b). Kassel project compares students' algebra achievement throughout fifteen different countries in the world. Also, this project provides information about students' difficulties in mathematics. In Turkey, according to results of a pilot test developed through Kassel project, elementary students were successful at operation based on algebra questions. However, students were not successful at equations and problems. The reason of these results indicated that students might have had misconceptions about these topics (Ersoy & Erbas, 2005). "As a result of the conducted literature review, it has been observed that there are scarcely any studies oriented to overcome the learning difficulties compared to the studies oriented to determine these difficulties" (Tatar & Dikici, 2008, p. 183). A current study in Turkey showed that since most students in three high schools in İzmir did not have enough conceptual knowledge about sets, they generally tended to give wrong answers in the test about sets (Moralı & Uğurel, 2010). Besides, students had problems with complex numbers since they had serious misconceptions about complex numbers (Turanlı, Keçeli, & Türker, 2007).

From the university perspective, undergraduate students also had some problems with mathematics topics and skills gained from high school. "Graphical work, the introduction of work based on geometrical ideas of symmetry, reflection and rotation, the use of coordinates, and the study of elementary statistics" were considered easy and beneficial for students, but algebra was difficult for students in England (Cockcroft, 1982, p.83). In a similar study, difficulties in learning mathematics at college in Canada generally arose from lack of basic mathematical concepts, algebraic skills, geometric skills, trigonometric skills, and inability of a verbal problem formulation (Tall, 1993). Similarly, basic mathematics operations, factorization, equations, absolute value, functions, and logarithm, were results of a study investigating "students transferring to the Malaysia Technology University who find difficulty with the mathematics that is pre-requisite for courses in engineering and other sciences" (Tall & Razali, 1993, p.2). Even while students were successful at solving problems including relations, they could not solve problems with graphs of functions in an open ended test (Zachariades, 2002). Rasmussen (1998) analyzed learning difficulties in differential equations of six undergraduate students as problems with reading a graph and with intuitive perception. Similar to previous research, students applied differential equations or integral in a question without making sure of validity and practical applications of these topics (Artigue, 1990). Additionally, Moore (1994) focused on approaches to a proof of undergraduate students in University of Georgia. Undergraduate students did not know most of mathematical concepts, notations, terminology. Besides, some did not find the starting point of a proof. In a similar way, Baker (1996) studied with undergraduate students and high school students to investigate students' difficulties in learning mathematical induction method. Even when undergraduate students knew abstract algebra; it was not enough to prove algebraic theorems. Students were not able to apply their knowledge (Weber, 2001).

The conditions and feedback about mathematics education in Turkey can be explored through international comparative studies such as Trends in International Mathematics and Science Study (TIMSS, 2013) and Program for International Student Assessment (PISA, 2013). These studies provide the participant countries with an opportunity to assess outcomes of their educational systems. For example, PISA aims to assess how 15-year-old students in OECD countries can use learned knowledge and skills in real life or literacy levels of students. PISA defines mathematics literacy as understanding importance of mathematics, ability to judge statement, ability to use mathematics depending needs in real life (PISA, 2013). This assessment provides a chance to compare educational attainment of those students among OECD countries and non-OECD countries with several focuses in different implementations such as reading skills (2000), mathematics literacy (2003), science literacy (2006), reading skills (2009), mathematics literacy (2012) and science literacy (2015).When Turkey' PISA results compared with OECD countries and non-OECD countries by years, achievement levels at mathematics were 33rd out of 41 in 2003, 43rd out of 57 in 2006 and 43rd out of 65 in 2009.

Similar results were obtained from TIMSS that evaluates the students' success at mathematics and science study around the world to improve those issues for future. Turkey had attended to TIMSS in 1999, 2007 and 2011. TIMMS (1999), students in Turkey was 31st out of 38 countries, TIMSS (2007) was 30th out of 59 countries and TIMSS (2011) was 24th out of 56 countries. The all years 'mathematics score was below the average. Besides, Turkey missed the chance to compare success of mathematics educational system in the years 1995and 2003 for TIMSS and in the year 2000 for PISA.

As evidenced by the results from TIMSS and PISA, Turkey can be said to have problems with mathematics education in order to develop skills and knowledge for mathematical literacy. It is obvious that students in Turkey are not able to effectively use mathematical knowledge in real life according to PISA results. Similarly, students are not successful at mathematics according to TIMSS results. Also, mean scores of Student Selection Examination to Higher Education Programs (OSYM) indicate a similar problem. Turkey had mathematics score at lower average for PISA. According to Student Selection Examination to Higher Education Programs from 1999 to 2002, students could answer less than half of mathematics questions except students in Science high schools. Furthermore, there was no difference at results of those exams among geographical seven regions of Turkey (Berberoğlu & Kalender, 2005). This picture can be the result of gaps in mathematics education. Typically, another research study in 2011 was conducted to evaluate PISA results of Turkey. It was reported that Turkey needs a educational reform which involves real and essential needs of students, teachers and schools in order to get satisfactory results and get a better position in the world ranks (Çelen et. al., 2011; Atlıhan & Konur, 2012).

Ministry of National Education (MoNE) put some reform actions into practice after low ranks of Turkey. A recent reform called 4+4+4 aims to (i) increase in students' literacy skills in several subject areas such as mathematics, science, and reading and (ii) to adapt Turkish education system according to the needs of information age. Dinçer (2012) stated that the new curriculum reform gave opportunity to students to have more flexible learning environment and curriculum. Before that, MoNE also makes revision in school curricula for several purposes, one of which is the need to reduce content of courses (Akşit, 2007).

Internationally, reduction in course content and/or selection of topics to be taught has been a topic of discussion, especially for the relationship between high school and higher education programs. Krejci (2011), in a study comparing two student groups who are graduates and failed to graduate higher education programs, found that there is a relationship between courses taken in high schools and university. For example, high school students in the state Michigan of the USA had a chance to track their mathematics course depending on learning and individual differences. The study pointed out students preferred to learn mathematics courses for their future educational and vocational goals (Updegraff, Eccles, Barber, & O'brien, 1996). Students, who took additional courses for college, got higher grades and academic achievement than students who did not take those courses (Long, Conger, & Iatarola, 2012). Moreover, perceptions of the university freshmen students in Zonguldak Karaelmas University on high school education and suggestions indicated that as

- there was a disconnection between high school curriculum and preparation for university
- no real life connection of high school curriculum
- there should be reduction in the high school curriculum
- high school curriculum should prepare students for university education
- first year of high school should include English and general courses for all students (Yanpar & Özer, 2004).

On the other hand, students in the United Kingdom have a chance to be ready for university education through their educational system. When the UK mathematics curriculum is discussed with components of courses, it provides each individual with opportunity to choose mathematics courses for higher education. The curriculum also includes mathematics courses for students, who will not study at university after high school, in order to let them use mathematics in real life or in vocational life (Lee, 2010). See Figure 1 to understand the UK mathematics curriculum for pre-higher education.

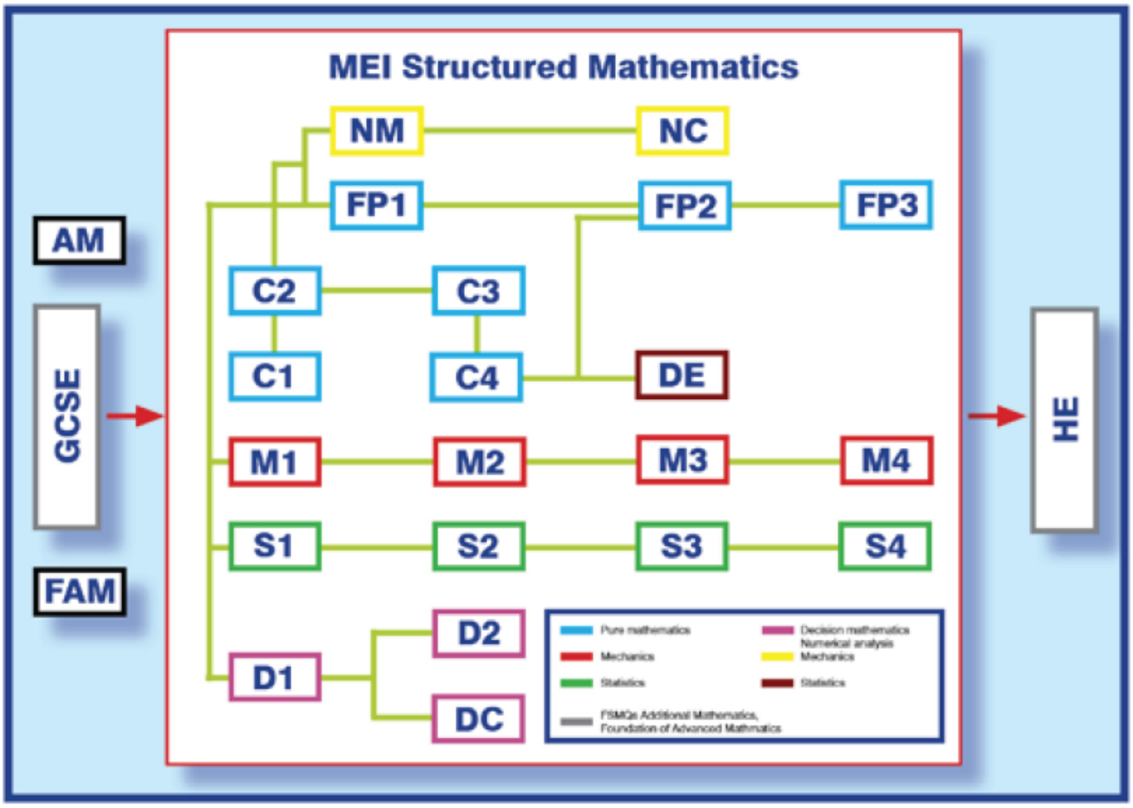

Figure 1. Mathematics in Education and Industry structured mathematics (Lee, 2010)

In the Figure 1, AM is Additional Mathematics, FAM is Foundations of Advanced Mathematics, NM is Numerical Methods, NC is Numerical Computation, FP is Further Pure Mathematics, C is Core Mathematics, DE is Differential Equations, M is Mechanics, S is Statistics, D is Decision Mathematics, DC is Decision Mathematics Computation (Lee, 2010).

Furthermore, students who will continue to university education or workplace, not only take courses but also need to have 21st Century abilities to use like knowledge of math, English, history, arts and science and skills like “critical thinking, problem solving, creativity, innovation, initiative and self-direction, leadership, adaptability, and digital media capabilities” (Blackboard Institute Staffs, 2004) in order to close existing gap between high school and college.

Problem

Teachers' ideas about mathematics curriculum consisted of several suggestions (Atlıhan & Konur, 2012) as:

- logic is important for all students
- high school mathematics curriculum has many topics, so some topics should drop out from curriculum. For example, limit, derivates and integration are advanced mathematics topics for engineering. They should not learn in high school. If a student wants to be an engineer, these topics can be taught at first year of university.
- high school curriculum should change based on students' needs, interests and readiness.
- science students should learn mathematics more than others
- students who choose science, Turkish-math and social studies tracks in high school should have different schedules and objectives which they need
- high school mathematics curriculum should be shaped according to school types.

As stated above and the background, many students in Turkey have difficulties in learning some mathematics topics and heavy content in high schools curricula. Additionally, there are limited research studies which examine high school mathematics curriculum as there are plenty of studies about elementary mathematics curriculum (Atlıhan & Konur, 2012).

The philosophy of Turkish national high school mathematics curriculum is "every student can learn mathematics" (MoNE, 2011; Çetinkaya, Güzel, & Karataş, 2010, p. 324), so students in Turkey currently are expected to learn same mathematics topics in high schools regardless of their future plans. In other words, Turkish high school mathematics curriculum has fixed mathematics topics and all high school students must learn these topics even if students have different learning hours according to their tracks such as Turkish-math, science and social studies. Students in Turkey do not have a chance to choose a path for their mathematics education based on their future plans though there are some curriculum examples in the world which prepare students for further education starting from high school. Instead of a fixed course curriculum, flexible or differentiating curricula should be based on students' future plans, especially for higher education programs they wish to study. This is also closely related to one of the principal aims of national education, which directs students according to their interest and ability (Turan, 2005). Since science and engineering departments heavily use mathematics, there is a relationship between high school mathematics topics and the higher education programs of science and engineering departments (Güner, 2008). On the other hand, there is no study investigating applicability of differentiating curricula for students who wish to study social science, which uses less mathematics. Whereas there are some research studies which explain generally the need of some mathematics topics and skills for social science departments. For instance, psychology department requires having thinking skills, language skills, information gathering and synthesis skills, and research methods and statistical skills (McGovern, Furumoto, Halpern, Kimble, & McKeachie, 1991). If a student graduated from psychology wants to find a job quickly, a skill-based educational life is more valuable than courses taken (Edwards & Smith, 1988; Murray, 1997). Learning statistics and mathematical knowledge provide psychology students with calculation, estimation and algebraic reasoning, understanding of such concepts as decimals, proportionality, probability, sampling and scale conversion.

The statistics (basic descriptive and inferential statistics) is an essential course for students of psychology (Lalonde & Gardner, 1993). Therefore, students who will study in psychology are needed to understand the use of statistics in psychology (Dilbeck, 1983; Hastings, 1982; Greer & Semrau, 1984; Lovie & Lovie, 1973). The learning statistics and probability has become widespread for social science and the social life. Therefore statistics and probability should teach to all due to having a link with mathematical literacy. After 1990s, it started to use for social sciences. As academic disciplines, statistics and probability in Belgium was taught as compulsory in law faculties during nineteenth century, so “jurists had known the statistics the most” (Ottaviani, 1991, p. 245). In Belgium, also history-students had to take statistics and probability courses in order to have knowledge about a country’s economics and politics (François & Bracke, 2006). Moreover, history-students should have knowledge, skills, values, questioning, reflection, analytical skills, understanding of democratic process (Fiford, 2011). According to research (Rifner & Feldhusen, 1997), chess develop critical thinking skills because with playing chess, students make plans strategically, find alternative ways, and make decisions. Therefore, in a history classroom, teacher taught history with chess in order to enable students to have critical thinking skills (Russell, 2010).

Considering each student has different needs and requirements for college education, some students will use advanced mathematical knowledge, such as complex numbers in their lives or at university while some students will not use such advanced mathematics knowledge. Surely, students, who intend to attend a further education such as law, psychology, or history, need to learn mathematics and some skills in high school. Therefore, there is a need to conduct a study that explores which mathematics topics and skills should be learned by high school students who intend to attend a further social science education such as law, psychology, or history.

Purpose

The purpose of this study is to explore and find out which topics and skills are important in high school mathematics curriculum for university education in social science departments such as law, psychology, and history. By this way, scientific evidence is sought for feasibility of differentiating curriculum. To this end, importance levels of mathematics topics were asked to university staff and people who work in private sector. Also mathematic topics, which exist in International Baccalaureate Diploma Program (IBDP, 2013) but not in MoNE, were also included to the present study.

Research questions

The research problems of the present study are the following:

1) Which topics and skills should be included in high school mathematics curriculum based on importance levels of the topics, for better preparation of high school students for university education in social sciences?
2) Do the social science departments differ in importance levels given for mathematics topics and skills obtained in high school?
3) Do the different institutions (universities and industry) related to social sciences differ in importance levels given for mathematics topics and skills obtained in high school?

Significance

There is an explicit problem in Turkish national mathematics curriculum in high school as all students are taught a uniform mathematics curriculum regardless of students' future plans in university education. The purpose of this study is to explore the mathematical knowledge and skills at high school needed to better preparation for university education in law, psychology, and history. It is expected that there should be a differentiation and variation in high school mathematics curriculum in the future depending on students' future plans, this study will give a scientific basis to inform policy makers for such planning.

Since 2005, curriculum developers and educators are talking about new education system in Turkey. Although there is not any official published position by the Ministry of National Education (MoNE) that explains the direction of new education reform, what kinds of changes new education system bring are written in the report of 18thMilliEğitimŞurası (18th Turkish National Education Council) between the dates 1-5 November 2010. According to the report of 18th Turkish National Education Council, 4+4+4 is the name of education plan that MoNE wants to change education 8-year-compulsory education system with 12-year-compulsory education system. It will start from 4-year primary education. Students may have elective courses regarding their competencies and interests. Students might have more elective courses according to their decisions for future education. Last 4 years will be for secondary education. Additionally, decisions taken by the council include students should take courses from class teacher until 4th grade and then branch teachers should give courses starting from 5th grade. It means MoNE thinks to give a chance to students to discover their own interests and abilities by trying some elective courses.

The most important part of these decisions is to give the researcher a chance to show the present study may help students to choose their mathematics courses according to their profession because in new education system, during or before high school students will have a chance to select which educational track they will take.

Moreover, there is a plan about designing a new mathematics curriculum leading students to be well-prepared for their professions as a result of new education system in the18th Turkish National Education Council. Consequently, my study will be beneficial for curriculum developers in Turkey in the future.

Definition of key terms

Curriculum should provide a liberating learning experiences through respecting for freedom of others, social and political empowerment, expressing thoughts independently, taking consideration of life of each individual (Kelly, 2009).

Generally, social science students should graduate with analytical skills, reasoning skills, critical thinking, intellectual flexibility, reflective judgment, communicating orally, writing skills, and good interpersonal skills (Hogan, 1991; Winter et al., 1981; Pascarella & Terenzini, 1991; Halpern, 1998; Kruger & Zechmeister, 2001). Teachers should focus on teaching questioning and controversial issues in social studies to let students use critical thinking process (Russell, 2010). Skills required in social sciences are communicating effectively, being persuasive, creative and critical thinking (Kuper, 2003).

Industry people work in a private service sector in law, history or psychology departments. These people should have at least undergraduate degree in such social science departments. Also, industry people are assumed as experienced social scientists in vocational life.

CHAPTER 2: REVIEW OF RELATED LITERATURE

Introduction

This literature review provides essential background information about mathematical knowledge and skills needed to be gained in high school to better prepare for university education in social sciences such as law, history, or psychology. In line with this aim, the literature describes theory of mathematics curriculum, advantages and disadvantages of differentiated mathematics curriculum, relations between high school mathematics curriculum and undergraduate education in terms of social sciences as emphasized by teachers and academics in mathematics education.

The literature review mentions general information about differentiated high school curriculum in the world, but also offers the new trends in mathematics education all around the world, mathematical literacy and problems of students in Turkey. It also includes some information about Turkish national high school mathematics curriculum and students' achievement at international assessments (e.g. TIMSS, PISA).

There are four main sections in this chapter: (1) theory of mathematics curriculum, (2) differentiated mathematics curriculum, (3) mathematics literacy, and (4) mathematics and social science education. In the first section on the theory of mathematics curriculum and knowledge and skills in mathematics, goals of mathematics education, components of curricula, and connections in the design of high school mathematics curriculum and undergraduate social science education will be explored through related literature. In this section, there will be information about goals of mathematics education in the United States, the UK with Cockcroft report and Turkey with the National Ministry of Education documents.

The second section will make a mention of differentiated curriculum: history of differentiated mathematics curriculum, ideas about differentiated mathematics curriculum, and evaluation of differentiated mathematics curriculum from different countries. This section will address mathematical knowledge and skills which is taught in the other countries versa Turkey at high school. Therefore, in this section Turkish national high school mathematics curriculum will be mentioned by the National Ministry of Education documents.

Then third section will emphasize the philosophy of mathematics literacy which is a new trend in mathematics education. There will be issues, knowledge, skills and functions of mathematics curriculum which provides the philosophy of mathematics literacy.

In the final section, mathematical knowledge and skills will be addressed for social science professions in the literature. How a mathematics curriculum can be adjusted according to preparation for university education will be addressed in this section.

Theory of mathematics curriculum

There are many different definitions of the term curriculum. Some of these definitions have similarity with each other, but some of them conflict (Schubert, 1986, p.26; Walker, 1990, p.4). Because definition of curriculum has been rewritten for centuries, it is obvious the term "curriculum" has many different definitions. Some research studies claimed that a curriculum was the content, standards, or instructional objectives that were based on students' interests and their learning styles. Others claimed that a curriculum was the set of instructional objectives that was mainly planned by policymakers or teachers' ideas and beliefs. In the United States Cuban (1976) defines curriculum and its components as , "A curriculum of a classroom, school, district, state, or (nation) is a series of planned events intended for students to learn particular knowledge, skills, and values and organized to be carried out by administrators and teachers." It can be said that curriculum can be seen as a useful tool to provide learner-centered ideology by some changes through stakeholders. However, when a teacher or administrator have power to change curriculum easily, it rarely may cause undesirable situations. For instance, if this teacher has a racist view, he/she may impose on students her racist ideas by curriculum. Therefore, Kelly (2004, p.3) emphasized that curriculum had to include democratic purposes and objectives. According to Kelly's book, a curriculum must consist of liberating experiences. Students should learn some skills such as being respectful to others' thought and values regardless of class, race or creed by the help of curriculum.

Considering curriculum is a well planned experiences for students, these experiences can prepare students for both real and vocational life. So curriculum covers intended knowledge and skills. Historically, high school mathematics curriculum was described as intended, taught, and attained curriculum in literature. Intended curriculum was defined in terms of recommended, adopted, official, formal or explicit (Cuban, 1976). This type of curriculum consisted of skills, values and knowledge which were identified desirable by policymakers (Goodlad, 1984). Taught curriculum was labeled as "implicit", "delivered" or "operational" curriculum (Cuban, 1976). It contains teachers' activities in classrooms such as questioning, using worksheets, textbooks, attempting ICT and presentations, etc. This is the formal side of taught curriculum. Taught curriculum also has an informal side which is labeled as the hidden curriculum (Goodlad, 1984; Jackson, 1981). During the lesson how teachers behaved towards students, how they explained their beliefs, or what behaviors could be model to students in classrooms are all about the hidden curriculum. In addition to this, taught curriculum can be seen in school in different ways. The researcher Cuban (1976) considered a school which had lots of extracurricular activities and courses to develop students' social and artistic skills. School administration would make a decision what skills were taught to students or what time students would be in school during these activities. Besides, teachers could make some changes in school life according to their own beliefs and ideas. "Whether such changes mean that the new goal is being achieved misses the point that the school, like the teacher teaches formal and informal lessons" (Cuban, 1976, p. 222).

In 1982 a committee of inguiry under the guidance of Sir Wilfred Cockcroft in the UK created an important report on teaching and learning mathematics in schools. This report argued that mathematics curriculum needed to prepare students for becoming competent citizens of modern life (or general mathematical skills for life), for getting a job, for helping to understand other disciplines, further university education in social sciences (history, law, sociology, philosophy, etc.) and in some mathematics-related departments such as engineering (Cockcroft, 1982).

In Turkey the National Ministry of Education takes in charge to develop mathematics curriculum and its components. Its document explains clearly objectives, knowledge and skills for mathematics education as preparation for life by mathematical capability, mathematical process skills (problem solving, communication, analytical thinking, etc.), using mathematics knowledge in solving real life problems, using mathematics in vocational life, exploring mathematics in nature, art, and social system (MoNE, 2011, 6-8). The purpose of Turkish national high school mathematics curriculum has similar features like other countries mentioned above. For example, Turkish education system wants to prepare students for their all parts of future life in order to provide an environment for students that they become happy, healthy, and productive for the country.

Differentiated mathematics curriculum

Carol Ann Tomlinson knowing the leader of differentiation and her colleagues defined differentiation as a method that teachers can modify “curriculum, teaching methods, resources, learning activities, and students products” in order to make students’ learning maximum in schools (Tomlinson, Brighton, Hertberg, Callahan, Moon, Brimijoin, Conover, & Reynolds, 2003, p. 121). So it is possible to adjust a curriculum with differentiation based on students’ differences. However, curriculum differentiation is an endless process and there is no single way to do it. When the literature was analyzed, several definitions were caught on differentiated curriculum. For instance, differentiated curriculum is a way of thinking about students, what students really need to know in school, how teachers can teach and how they can learn, instruction that meets the needs, abilities, and interests of students (UNESCO, 2004). Similarly, differentiated curriculum is having high expectations for each student, allowing students to choose what they want to learn and ways to learn, but differentiated curriculum is not an individualized instruction (Tomlinson & Allan, 2000; State Policy of New South Wales, 2004). However, it should be considered that each student is different and has different needs, interests, abilities, backgrounds, or different ways of learning (UNESCO, 2004).

The mathematics tracking has been a topic of discussion for years in educational literature. Discussions are generally about whether mathematics tracking is democratic or not. Paul Ernest, who is well-known philosopher of mathematics and mathematics education, asserts that differentiated curriculum by tracking mathematics courses with regard to students needs and future plans is the only democratic way for all in schools. Since he argues students should have a chance to choose their mathematics courses according to their interests and future plans, he does not justify general mathematics curriculum or compulsory mathematics courses. He uses three tracks for students: tracks for those who want to work mathematics related work such as “mathematics, engineering or information technology”, tracks for those who will work in “non-mathematics related work such as the humanities, or vocational tracks for those who will not go to university. So Ernest thinks that there is no need to teach all students to all mathematics topics. Ernest’s mathematics curriculum (2002) is based on mathematical empowerment (mathematical ability), social empowerment (ability to use mathematics in real life), and epistemological empowerment (a personal sense of confidence about mathematics). All in all, through these empowerments he believes that students will use, interpret, and criticize mathematics in every part of life (Ernest, 1991; 1998; 2002).

In most countries, students can take courses as a differentiated mathematics curriculum depending on their future plans. Based on the outcomes of studies in the United Kingdom, curriculum planners developed differentiated mathematics courses in public schools. For example, Mathematics in Education and Industry Project (MEI) which was set up in 1963 aimed to make their pupils prepare for future vocational life and higher education (Cockcroft, 1982). According to Cockcroft report (1982) in the United Kingdom, mathematics curriculum needs to prepare high school students for becoming competent citizens of modern life by developing general mathematical skills for life, technical fields and vocations that do not require a full 4-years university education (vocational mathematics), further university education in technical fields (basic sciences, engineering and medicine) and further university education in social sciences (history, law, sociology, philosophy, etc.).

National Council of Teachers of Mathematics (NCTM) claims that whatever decision students make about their future occupational life, students should have a strong understanding of mathematics to be successful at college or at occupational life (NCTM, 2004). The New Zealand Curriculum indicates that mathematics helps students develop abilities to overcome difficulties at home, at work and in the community (New Zealand Ministry of Education, 2007).

There are reports for each state in the United States, which indicate common core state mathematics standards for college and career. One report describes which mathematics topics should be learned by all students to have skills such as solving realistic problems, reasoning abstractly, thinking critically, modeling with mathematics, and using technological tools appropriately (Common Core States Standards Initiative, 2012). The United States' high school students generally learn mathematics topics of number and quantity, algebra, functions, modeling, geometry, statistics and probability. The Regional Educational Laboratory Central (Kendall et al., 2007) in the United States prepared a report for the Institute of Education Sciences (IES) to identify topics of the language arts and mathematics, where students will use in college and the workplace. "State standards for high schools in a majority of Central Region states cover just 57 percent of mathematics topics" that will play a vital role in college and the workplace. According to these reports, mathematics in the United States is mostly based on vocational mathematics. This means students in the United States learn mathematics topics which will be important for their further education or vocational life before attending a college.

In Turkish schools, students are expected to learn same mathematics content in the same way at the same time. In other words, Turkey has a national high school mathematics curriculum designed by Board of Education. The mathematics high school curriculum was prepared by searching current educational research studies in the world, curriculums of developed countries and teaching experiences of mathematics education at past in Turkey. The main vision of Turkish mathematics high school curriculum is based on “every student can learn mathematics”. This vision follows a unique program, which all students should learn fixed mathematics topics by Turkish education council in advance. Therefore, Turkish high school mathematics curriculum is not considered as having characteristics of differentiated curriculum. Students do not have a chance to choose their courses in mathematics depending on their needs and interests in Turkey. In addition to that the curriculum includes an intensive mathematics knowledge, which has 6 learning domains and in totals 63 sub-learning domains of those domains: logic, algebra, trigonometry, linear algebra, probability and statistics, calculus and students are required to learn those topics during high school education (Turkish National High School Mathematics Curriculum, 2011). There is a research study which compares high school mathematics curriculum of Turkey with that of Canada, and Germany (Çetinkaya, Güzel, & Karataş, 2010). The data were collected by document analysis of these three countries’ curriculum guidebooks as a qualitative analysis method. The study indicated that the philosophy of Canadian high school mathematics curriculum advocate the idea that each student has a different personal future from other students, so mathematics should serve each student according to students’ interests and needs while the philosophy of German considers high school mathematics curriculum is that mathematics should prepare students to vocational life and private life to solve problems with rational solutions. However, the study claimed that the philosophy of Turkish high school mathematics curriculum is based on the idea “everybody can learn mathematics” (Çetinkaya, Güzel, & Karataş, 2010, p.324). In conclusion, many countries have their own high school mathematics curriculum which can be shaped by each country’s special desire and philosophy. Even if there are common mathematics topics such as algebra, probability, trigonometry, linear algebra, and calculus learning areas in Turkey, other mathematics topics vary according to countries’ philosophy (Çetinkaya, Güzel, & Karataş, 2010, p. 324). For example, despite there is no comprehensive unit of statistics in Turkish high school mathematics curriculum, both Canadian and German high school mathematics curriculum have. Additionally, although the topic of induction is not included in Canadian and German high school mathematics curriculum, it is only included in Turkish high school mathematics curriculum among three countries. Contrary to Turkey, while for example Canadian high school mathematics curriculum does not cover the topic of complex numbers, German high school mathematics curriculum has the topic of complex numbers as an elective course (Çetinkaya, Güzel, & Karataş, 2010). Thus there is a need a mathematics curriculum that prepares high school students for further education. Therefore, curriculum developers in Turkey should pay attention to lacks of Turkish high school mathematics topics and skills to better prepare students for further education, vocational life and private life.

Mathematics literacy

The Program for International Student Assessment (PISA) is known “as a system of international assessments that measures 15-year-olds’ performance in mathematics literacy, science literacy and reading literacy every 3 years” (Baldi et al., 2007, p. 3). The PISA which is sponsored by the Organization for Economic Cooperation and

Development has its own definition of mathematics literacy. Mathematics literacy is a set of individual skills to understand the role of mathematics in the world and to transfer mathematical knowledge to “individual’s private life, occupational life, and social life, as well as life of a citizen of a community” (OECD, 2003, p.25). This definition states that mathematics literacy is about engaging individuals in exploring and solving realistic problems and contexts, which are linked to individuals’ daily life and occupational life. According to the South African National Curriculum Statement (Department of Education Staffs, 2003, p.10), mathematics literacy is based on real life problems of mathematics. If individuals learn how to solve real life problems of mathematics, this learning helps individuals think numerically and spatially. Thus, individuals interpret and critically analyze to deal with problematic everyday situations. The International Program Committee for International Commission on Mathematical Instruction (ICMI) Study-14 summarizes mathematics literacy as the domain of “applications and modeling of mathematics”. The study links mathematics with real life through a diagram: “modeling ⇒ moving from reality → to mathematics and applications ⇒ moving from mathematics → to reality” (ICMI, 2002, p. 149-171). Furthermore, there is another definition which describes mathematics literacy in terms of the literacy in a language. The literacy is a tool for social interaction with the community. Similarly, mathematics literacy is a way for understanding language of mathematics. A mathematically literate person can use mathematics as a communication tool in life (Mbekwa, 2006). There is a little consensus on the definition of mathematics literacy; all definitions of mathematics literacy indicate that mathematics literacy is a tool not only for solving real life problems but also for communicating mathematically (Berberoglu & Kalender, 2005).

According to results from PISA which assess students level of mathematical literacy once a three year, students had mathematics score 423 with standard error 0.75. Turkey was 28th among OECD countries and non-OECD countries in 2003. PISA (2006) 160 school, 4942 students attended in Turkey. According to results students in Turkey had mathematical literacy average 424 with standard error 4.9 Turkey was 29th out of 30 all countries and 43rd out of 57 all countries those attended to the PISA. PISA (2009), Turkey was 32nd out of 34 all countries with score 445 and 43rd out of 65 countries. PISA (2012) will explain 2013 December. Based on results from PISA, it can be said that students in Turkey are behind of other countries in terms of mathematics literacy. Even though Turkish national high school curriculum aims to equip students with mathematical knowledge and skills for real life and vocational life, it is obvious that Turkish national high school curriculum has problems to achieve educational purposes with current curriculum.

Mathematics and social sciences education

In the UK there was a report published to understand mathematics topics for pre-university education in order to be well-prepared for university-level programs. In March 2008, promoting achievement, valuing success: a strategy for aged 14-19 qualifications had three routes to higher education (Lee, 2010, p. 4) as "apprenticeships, diplomas, and general qualifications, including the General Certificate of Secondary Education (GCSE), and the General Certificate of Education, Advanced Level (GCE A Level)". A Level includes two components: AS (Advanced Subsidiary) in the first year and A2 Level in the second year. Apprenticeships need work with on-the-job training, qualifications and progression, diplomas require to work in classroom and practical with studying functional mathematics at appropriate level, general qualifications are required to have a proof of attainment in mathematics to be used for higher education admissions tutors. Many universities in the UK have tested their undergraduate students' mathematical knowledge, fluency and understanding at the beginning of the semester to determine what these students know about mathematics before starting to higher education. Students after GCSE do not usually do mathematics. GCSE has two types: Foundation Tier and Higher Tier. "Students entering GCSE Mathematics at Foundation Tier will not study as much mathematics as students take Higher Tier" (Lee, 2010, p. 6).

The students who are studying Foundation Tier do not learn topics below while students cover these topics in Higher Tier:

- Negative and fractional numbers
- Working with numbers in standard form (scientific notation)
- Reverse percentage calculation
- Working with quantities which vary in direct or inverse proportion
- Solution of linear simultaneous equations by algebraic methods
- Factorizing quadratic expressions and solution of quadratic equations
- Plotting graph of cubic, reciprocal, and exponential functions
- Trigonometry
- Calculation of length of arc and area of sector of a circle
- Cumulative frequency diagrams, box plots, and histograms
- Moving averages
- Three diagrams, and associated probability calculations

So students who will attend the Higher Tier in GCSE should learn those topics above. There is also IGCSE curriculum in the UK. Students who want to study should take some additional courses to GCSE such as introduction to calculus and matrices.

AS mathematics have C1 and C2 compulsory modules and one of applied modules: mechanics, statistics, or decision mathematics. C3 and C4 are compulsory for A2 level as well and an applied module. Some students prefer AS or A level statistics. A level statistics can be seen as an essential background for students planning to study "business, biology, psychology, or social sciences at higher education level" (Lee, 2010).

Cambridge university started to offer students to have a better preparation before higher education to have mathematical knowledge and skills needed for university study since 2010 (Lee, 2008). Gamoran and Hannigan (2000) emphasized that sociologists have shown that a curriculum can be differentiated according to students' preferences that needed to plan future life. That is, high school curriculum can shape for ninth grade students as general math, pre-algebra, algebra, and geometry. These courses will help students to make a plan about their future career and follow mathematics courses that they would like to study further years of high school. There was an example of high school which offered a two-year general math. One third of students at ninth grade, who would never learn mathematics, wanted to take general math (Tucker & Coddling, 1998). There are recent research studies about college and career readiness in USA. Conley (2011) pointed out that the preparation for college is needed to enroll any academic program or getting career at future. Standards for university success (2003) collected information about what could be for better preparation for university from 400 faculty which were examined knowledge and skills for university success. American Diploma Project Benchmarks (2004; 2008) identified employers' opinions from 22 occupations about what could include college and career readiness. Texas College and Career Readiness Standards (2009) validated with a team of educators from high school and university.

The Common Core State Standards (CCSS) in 2011 aimed to define knowledge and skills that students should have from high school to be ready for in entry-level, credit bearing academic college courses, and in workforce training programs. David Conley and his team at the Educational Policy Improvement surveyed 1,815(420 social science professors from economics, psychology, sociology, U.S history and U.S government two- and four-year college professors in twenty-five different subjects, from English and math to history, business, social science and computer science, were asked how relevant and important various Common Core standards are to their courses. In terms of mathematics standards for social science professors, number and quantity (60 out of 420), algebra (58 out of 420), functions (52 out of 420), statistics and probability (183 out of 420), mathematics practices (223 out of 420) were generally found to be applicable for higher education coursework while the geometry (13 out of 420) standards, were not. Among skills needed for improvement for students most were among problem-solving and critical-thinking requirements. Especially statistics were more important for social science and science than other departments. Standards for each conceptual category of mathematics are listed below (Conley et al., 2011):

Number and quantity

- Real numbers systems
- Quantities
- The complex number systems lowest rating
- Vector and matrix quantities

Algebra

- Seeing structure in expressions
- Arithmetic with polynomials and rational expressions lowest
- Creating equations
- Reasoning with equations and inequalities

Functions

- Interpreting functions
- Building functions
- Linear, quadratic, and exponential models
- Trigonometric functions

Geometry

- Congruence
- Similarity, right, triangles, and trigonometry
- Circles
- Expressing geometric properties with equations
- Geometric measurement and dimension

- Modeling with Geometry

Statistics and probability

- Interpreting categorical and quantitative data
- Making inferences and justifying conclusions
- Conditional probability and the rules of probability
- Using probability to make decisions

Mathematics practices

- Make sense of problems and persevere in solving them
- Reason abstractly and quantitatively
- Construct viable argument and critique the reasoning of others
- Model with mathematics
- Use appropriate tools strategically
- Attend to precision
- Look for and make use of structure
- Look for and express regularity in repeated reasoning.

When the curriculum of social science departments in Turkey is examined in terms of mathematics courses, psychology department generally prepares students at first year for statistics, calculus, and computing, law cares mostly statistics, computing, economics and finance, however, history does not have any course related to mathematics at university (Bilkent, 2013; METU, 2013; Hacettepe, 2013). Law education has some requirements as law students should have main courses like sociology, philosophy, logic, mathematics, economics and Turkish to enable them to think, reason, understand cause and effect relations, and to have analytic reasoning skills which are needed to become a jurist (Çelikel, 1996). Because all students take a uniform standard curriculum in high school especially in mathematics, students do not necessarily come prepared for studying law at university in terms of the knowledge and skills needed in law such as thinking, questioning, doing research, being aware of problems and solving them (Öztürk, 2010). Therefore, when they come to the university with experience mostly in rote learning, students have some difficulties as they may not have developed reasoning skills, not being able to use their logical skills very well or not being able to solve problems. This problem in educational system causes that law students have difficulty in becoming a ‘jurist’ and many people believe that they are trained like ‘technicians’ (Karayalçın, 2008).

As part of law education at undergraduate level, general mathematics, logic, statistics, and economy are suggested for better preparation to university education by Öztürk (2010) among other courses. These courses and others are expected to support and develop law students’ analytical reasoning skills, logical thinking skills, quantitative reasoning skills, critical thinking skills, and skills for controlling and dealing with uncertainty, and problem solving skills. In addition, students should have critical reading skills, writing skills, oral communication and listening abilities, general research skills, task organization and management skills, the value of public service and promotion of justice. These skills, abilities and values are necessary to become a professional in law (Ansay, 1969; Vice Provost for Undergraduate Education, 2007). A professional in law should meet society’s needs in all spheres of life that certainly includes financial and technical sectors. Although reasoning or problem solving are identified as explicit goals in our national mathematics curriculum on paper, it is hardly the case that these goals are realized nor are students trained to have effective mathematical reasoning or problem solving skills.

In the light of the problem section and related literature, there is a problem in high school mathematics education in Turkey. Therefore, a special mathematics curriculum for further education becomes part of a solution. The aim of this research is to explore which mathematical knowledge and skills students are needed in high school to be successful at their future academic studies in social sciences.

Summary

In this chapter, under the theory of mathematics curriculum: differentiated mathematics curriculum, tracking mathematics, career and college readiness, mathematics literacy, mathematics education for social science were summarized through the relevant literature. Besides, Turkish national high school curriculum, relations between high school curriculum and college curriculum for achievement, and trends in mathematics curriculum were also reported.

When compared the mathematics curriculum with other countries, there were some similarities about visions that are proper for preparing students for real life and providing students with appropriate mathematical knowledge and skills. However, it is considered that Turkey's national mathematics curriculum does not differentiate students or content. While some countries had some standards for career and college readiness, there is no explanation about career and college readiness or pre-university education in the national curriculum. Typically, since Turkey has a standard curriculum for all students, students, who want to study in any social science department, have limited preparation and help for their career. So this research study will explore the mathematics topics which can be helpful for achievement in the university for social science students by the help of ideas of experts. At the end of this study, experts' ideas will be reported that what they think about which mathematics topics can applicable in high school for their courses at university. Thus, this study will give an idea about gaps and strong points in national mathematics curriculum in terms of providing students with readiness for social science education at university.

CHAPTER 3: METHOD

Introduction

In this chapter, methodological issues related to the present study are given. The purpose of the study is to determine the importance levels of high school mathematics topics in MoNE and IB mathematics the topics and mathematical skills from high school curricula, based on importance levels stated by people from university and industry related to social sciences. To this end, importance levels were asked the participants and responses were recorded using a survey. Details of the research are given in the subsections below.

Research design

The present study used the survey method with a cross-sectional research design. Surveys have two types of studies which might be cross-sectional study or longitudinal study in order to generalize results from a sample to population (Babbie, 1990; Creswell, 2003). Because of using a cross-sectional research design in the study, participants' opinions were asked at one time from a predetermined sample during the data collection process. A close-ended survey including 49 mathematics topics and 8 mathematical skills were prepared to obtain a quantitative description of opinions of the sample (Creswell, 2003). The participants from the universities and the industry were asked to rate importance levels of the mathematics topics and mathematical skills using a Likert scale.

Context

This study was conducted in Ankara, Turkey, with the participation of university staff from social science departments (law, psychology and history) and people who work in industry. Most academics had completed at least their doctoral degrees in social science education while half of industry people had only a degree of social sciences from university. The common feature of these universities was that the language of education was in English. Academics were selected from a private university and a state university in Ankara. Departments: law, psychology, and psychology were more popular than other social science departments among students according to university preference in the entrance exam. So these three departments were studied as content.

Participants

The participants of this study (n=50) were university staff in social sciences such as law, psychology, and history departments and people who work in the industry from psychology and law departments. The present study was conducted with 40 academicians from departments of law, psychology and history at Bilkent University and Middle East Technical University (METU) in Ankara. Also 10 people who work in the industry were also included. 25 academicians were from Bilkent University and 15 academicians from METU.

University staffs and participants from industry had mostly at least doctoral degree in their own departments. Since these university staffs work currently as an educator in any department in the universities, it was crucial to get opinions of academics to investigate importance of mathematics topics for their teaching subjects in the university. So they could have an opinion as an expert about mathematics topics for university departments, which have been taught in high school. People who work in the industry were important to the study because their opinions could provide a result as vocational life for social science education. When conducting analyses, participants were grouped into two as university staff and people from the industry. Table 1 shows the distribution of participants.

Table 1
Distribution of the participants

		Departments			
Institution	Title	History	Law	Psychology	Total
Bilkent	Ass. Prof. Dr.	1	1	1	3
	Assoc. Prof.	0	3	0	3
	Dr.	4	3	2	9
	Professor	0	3	0	3
	Research Assistant	1	6	0	7
	Total	6	16	3	25
METU	Dr.	0		2	2
	Professor	0		2	2
	Research Assistant	2		9	11
	Total	2		13	15
Industry	PHD		2	1	3
	Lawyer		6	0	6
	Professor		1	0	1
	Total		9	1	10

Instrumentation

A questionnaire including 49 Likert type items and 8 mathematical skills were created by the help of an expert's opinion who works at Turkish Board of Education, Turkish national mathematics curriculum and IBDP curricula. All mathematics topics from 9th, 10th, 11th, 12th of MoNE curriculum and additional mathematics topics from IBDP curricula, in which Turkish national mathematics curriculum do not exist, and 8 mathematical skills were asked importance levels given a five-point Likert scale (from *1. not at all* to *5. very important*). When taking the topics only general headings were taken into consideration, subtopics were not included to the present study. Also 8 skills considered to be required by social science education were also added to the questionnaire. Thus, the questionnaire had two sections: mathematics topics with 49 items and mathematical skills (8 items), each measured with 5-point Likert scale. In addition to that participants were allowed to give responses for each question as qualitative data, but the participants did not respond any of them. So, the survey was not analyzed in qualitative way. The questionnaire is given in Appendices section (Appendix A).

Method of data collection

The questionnaire was prepared online through data base. Data collection was done as to ways: electronic version of the questionnaire and printed version of the questionnaire. After all university staffs' email addresses were found on the university website, an email explaining the questionnaire and the study was sent to get an appointment. If the university staff accepted to have a meeting about talking and responding questionnaire, the questionnaire was provided to fill in by hand. The university staff could have a chance to ask any question about items in the questionnaire. Second way was accepting to respond questionnaire by online using a data base platform. All responses were kept automatically into this data base by clicking send button at the end. According to Nesbary (2000), the data could collect with the help of online prepared surveys. The time of responding questionnaire was saved by the data base. It took 15 minutes on the average to complete the survey. All data were collected into two months. The people who work industry in Ankara were selected randomly among having doctorate degree. These people responded the questionnaire by online. All data collected via the printed version were entered into an electronic file and combined with the data obtained from the online version.

Table 2

Mathematics topics according to grades

9th grade mathematics topics

- Logic (truth tables, propositions etc.)
- Mathematical proof methods (Induction, proof by contradiction, etc.)
- Sets (and operations with sets)
- Relations (relations between sets)
- Concept of function (domain and range sets of functions, operations on functions)
- Modular arithmetic (the numbers that are not in 10 base)
- Exponential numbers and root numbers
- Divisibility of integers
- Rate/proportion
- Vectors in analytic plane, operations and vectors
- Cylinder, cone, sphere, prism, pyramid and their properties
- Synthetic geometry: point, line, angle, ray, plane, space
- Synthetic geometry: angles and areas of triangles and polygons
- Line and circle properties in the analytic plane
- Distance and applications in analytic plane
- Tessellations on the plane (Escher's drawings)

10th grade mathematics topics

- Polynomials (operations on polynomials and factorization)
- Quadratic equations and functions
- Trigonometric ratios (sine, cosine, etc.)
- Trigonometry (acute angle ratios, trigonometric functions, compound angle formula, trigonometric equations)
- Similarity theorems for triangles
- Transformations on the plane (translation, revolution, reflection)
- The proof of theorems in geometry

11th grade mathematics topics

- Counting methods (permutation and combination)
- Pascal triangle and Binomial expansion
- Complex numbers
- Exponential equations and functions
- Logarithmic equations and functions, natural logarithm
- Proof by induction and proof methods
- Sequences (arithmetic and geometric sequences)
- Matrices, matrices operations and determinants
- Linear equation systems and applications
- Analytical investigation of conics (parabola, hyperbola and ellipse)
- Circular region and area of circular region, the angles of a circle, circumference of a circle
- Basic probability concepts (experiment, output, sample, conditional probability, independent and dependent events and others)
- Statistics - Data presentation (graphs such as column, line, box, scatter, histogram etc. graphs)
- Statistics-central tendency and dispersion

12th grade mathematics topics

- Limit and continuity
- Drawing and interpreting functions graphs
- Derivatives and their application
- Integration (Indefinite integrals, definite integrals, application of integrals)
- Vectors in space (three dimensional), operations and vectors
- Plane in space and analytic properties

IBDP mathematics topics

- Finite random variables
- Statistical distributions (binomial, Poisson, chi-squared, and normal distributions)
- Bayes' theorem
- Significance and hypothesis testing
- Correlation and regression
- Interest, depreciation and cost

Table 3
Mathematical skills

- Mathematical problem solving skills (ability to apply mathematical concepts and rules effectively in order to solve unordinary problems)
- Mathematical modeling (ability to construct a mathematical model satisfying and explaining matters in science, social science, engineering, economics, etc. through mathematical concepts and language)
- Mathematical reasoning (ability to understand logic behind mathematical rules, generalization and solutions, ability to go beyond memorization of mathematical formulas)
- Mathematical communication (ability to explain mathematical thinking process by standard mathematical terminology and symbols the way that other people could understand it
- Mathematical relations (ability to establish a connection among mathematical concepts, other science disciplines and real life
- Mathematical representations (ability to demonstrate a mathematical concept in different ways as through algebra, graph, table, diagram, etc., ability to make a link between relations and transitions)
- Analytical reasoning skills (ability to abstractly be aware of parts and relations among parts in order to understand whole of proceeding of ability
- Critical thinking skills (ability to think systematically to evaluate validity of argument, speech, news, or research)

Method of data analysis

First of all, data cleaning was made on data sheet. Missing coding was checked and data from participants with very low rates of response were removed from the data set. Mathematics topics were categorized with respect to grade levels of MoNE for ease of analysis. The 8 skills were not grouped. All responses were analyzed in mean differences of the importance of the topics with respect to departments and institutions. Since data was collected from three different departments and three different institutions, one-way ANOVA was preferred to apply in order to analyze data for those. In all analyses, alpha level was set to 0.05.

When conducting ANOVA-analyses, scores expressed in terms of 5-point Likert scale were considered to be in the interval scale, while they are originally in the ordinal scale, which means that intervals among the scores are not equal. But, it is difficult to determine equalities of distances between categories. Therefore, there are some discussions on whether parametric tests such as ANOVA can be conducted on data from Likert scale. However, several researchers proved that Likert scales can be treated as having interval scales (Baggaley & Hull, 1983; Maurer & Pierce, 1998; Vickers, 1999). That is, the use of parametric tests is acceptable through such an assumption and also the situation provides more power (Winter & Dodou, 2010). All assumptions of statistical analyses were considered before ANOVAs were conducted in the study. Also, ANOVA results were reported even if the assumption of variances was not met homogeneity.

CHAPTER 4: RESULTS

Introduction

In this chapter, results of the statistical analyses are presented in order to determine both importance levels and mean differences of mathematics topics and mathematical skills across departments (history, law, psychology) and institutions (university and industry). Differences in importance levels for mathematics topics and mathematical skills assigned by university staff and those who work in industry were investigated with respect to grade level 9, 10, 11 and 12, and also for International Baccalaureate Diploma Program (IBDP) curricula. The same differences were also investigated in institutions as Bilkent University, METU and industry. First, the importance levels were analyzed by means of each topic and skill and were represented by figures. The figures help to divide topics and skills into two sections as important topics and non-important topics according to departments and institutions. Secondly, One-Way ANOVAs were conducted to analyze significant mean differences among groups. Then, if a significant mean difference was indicated by One-Way ANOVA, Post-Hoc analysis was carried out to find out the source of mean difference among groups. For the Post-Hoc analyses, LSD was used if variances of the groups were equal, otherwise Dunnet's C test were reported. The names of topics or skills were shortened in the tables and the figures, for full reference see Chapter 3. Also, all mean scores and standard deviations were given in the appendices section in order to see full importance levels. Results of the analyses were presented separated by grade levels for ease of following.

9th grade mathematics topics

Importance levels of the 9th grade mathematics topics for the departments

The responses of 50 participants for 16 topics were analyzed in descriptive ways to come up with importance levels for each topic among history, law, and psychology departments. The Figure 1 was drawn by using mean scores of topics. So, if the mean score of any topic was greater than 3.00, it was accepted as an important topic.

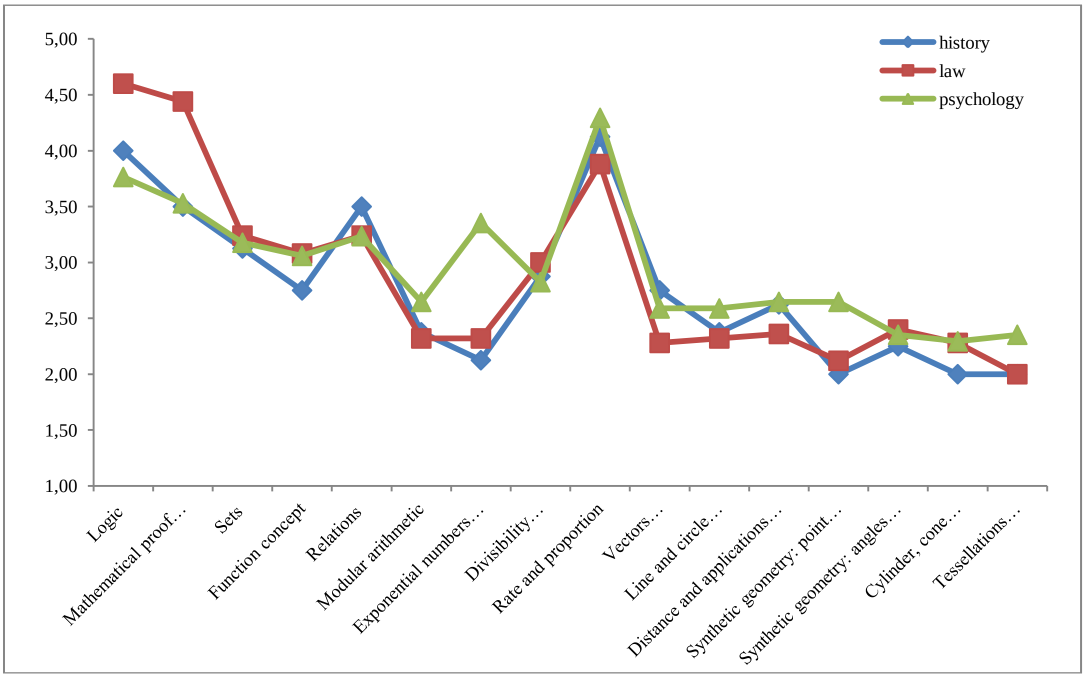

Figure 2. Means of 9th grade mathematics topics across the departments

As can be seen from the Figure 2, logic, mathematical proof methods, sets, relations, rate and proportion were important for three departments, as they have mean scores greater than 3.00. Function concept seemed to be important for law and psychology and not in history. Exponential numbers and surds only were important for psychology. Since divisibility of integers, modular arithmetic, vectors in analytic plane, operations and vectors, cylinder, cone, sphere, prism, pyramid and their properties, synthetic geometry: point, line, angle, ray, plane, space, synthetic geometry: angles and areas of triangles and polygons, line and circle properties in the analytic plane, distance and applications in analytic plane, tessellations on the plane had means less than 3.00, they were not important for any of three departments.

Differences between the departments

One-Way ANOVA was used to investigate mean differences of 9th grade mathematics topics across the departments by referring to the responses of 50 participants for 16 topics. Table 4 shows the results of the One-Way ANOVA analyses conducted.

Table 4
Results of ANOVA for 9th grade mathematics topics across the departments

Topic		Sum of Squares	df	Mean Square	F	Sig,
Logic	Between	7.52	2	3.76	3.60	.04
	Within	49.06	47	1.04		
Mathematical proof methods	Between	10.59	2	5.29	7.68	.00
	Within	32.40	47	0.69		
Sets	Between	0.09	2	0.05	0.04	.96
	Within	59.91	47	1.28		
Function concept	Between	0.70	2	0.35	0.26	.77
	Within	62.28	47	1.33		
Relations	Between	0.46	2	0.23	0.20	.82
	Within	55.62	47	1.18		
Modular arithmetic	Between	1.12	2	0.56	0.42	.66
	Within	63.20	47	1.35		
Exponential numbers and surds	Between	13.32	2	6.66	4.88	.01
	Within	64.20	47	1.37		
Divisibility in whole numbers	Between	0.33	2	0.17	0.09	.91
	Within	85.35	47	1.82		
Rate/proportion	Between	1.78	2	0.89	0.89	.42
	Within	47.04	47	1.00		
Vectors in analytic plane...	Between	1.76	2	0.88	0.50	.61
	Within	82.66	47	1.76		
Line and circle properties…	Between	0.75	2	0.37	0.21	.81
	Within	83.43	47	1.78		
Distance and applications…	Between	0.98	2	0.49	0.28	.76
	Within	81.52	47	1.73		
Synthetic geometry: point, line…	Between	3.56	2	1.78	1.53	.23
	Within	54.52	47	1.16		
Synthetic geometry: angles…	Between	0.14	2	0.07	0.05	.95
	Within	69.38	47	1.48		
Cylinder, cone, sphere, prism…	Between	0.55	2	0.28	0.16	.85
	Within	80.57	47	1.71		
Tessellations on the plane	Between	1.40	2	0.70	0.57	.57
	Within	57.88	47	1.23		

According to the results, significant mean differences were found for the topics logic $F(2, 47) = 3.60$, $p = .04$, mathematical proof methods $F(2, 47) = 7.68$, $p = .00$, exponential numbers and surds $F(2, 47) = 4.88$, $p = .01$. On the other hand, sets, function concept, relations, modular arithmetic, divisibility of integers, rate and proportion, vectors, operations and applications of vectors, line and circle properties, distance and applications, synthetic geometry: point, line..., synthetic geometry: angles and areas..., and tessellations no significant mean difference was found, ($p >$ .05). In order to further investigate sources of mean differences among the departments, Post-Hoc analyses were conducted for topics on which significant differences were found.

Table 5
Results of Post-Hoc tests for 9th grade mathematics topics across the departments

Topic	Post-Hoc Test Used	Department (i)	Department (j)	Mean Difference (i-j)
Logic	LSD	History	Law	-0.60
			Psychology	0.24
		Law	History	0.60
			Psychology	0.84(*)
		Psychology	History	-0.24
			Law	-0.84(*)
Mathematical proof methods	LSD	History	Law	-0.94(*)
			Psychology	-0.03
		Law	History	0.94(*)
			Psychology	0.91(*)
		Psychology	History	0.03
			Law	-0.91(*)
Exponential numbers and surds	LSD	History	Law	-0.20
			Psychology	-1.23(*)
		Law	History	0.20
			Psychology	-1.03(*)
		Psychology	History	1.23(*)
			Law	1.03(*)

* The mean difference is significant at the .05 level.

According to Post-Hoc analyses results, for the topic logic, significant difference was only found between law and psychology departments. So the logic for law department was more important than psychology. For the topic mathematical proof methods, (i) law and history and (ii) law and psychology were found to be statistically different. Mathematical proof methods had less importance levels in history and psychology than law. For the topic exponential numbers and surds, (i) history and psychology and (ii) law and psychology were found to be statistically significant different. While exponential numbers and surds were important for psychology significantly, it was not important for law and history.

Importance levels of 9th grade mathematics topics for the institutions

All 9th grade mathematics topics were analyzed to find out importance levels based on institutions (Bilkent University, METU, and industry people). Therefore, the same process was applied to analyze as the process of importance level of 9th grade mathematics topics for departments above. Figure 3 helps showing the means of topics which are greater than 3.00 easily.

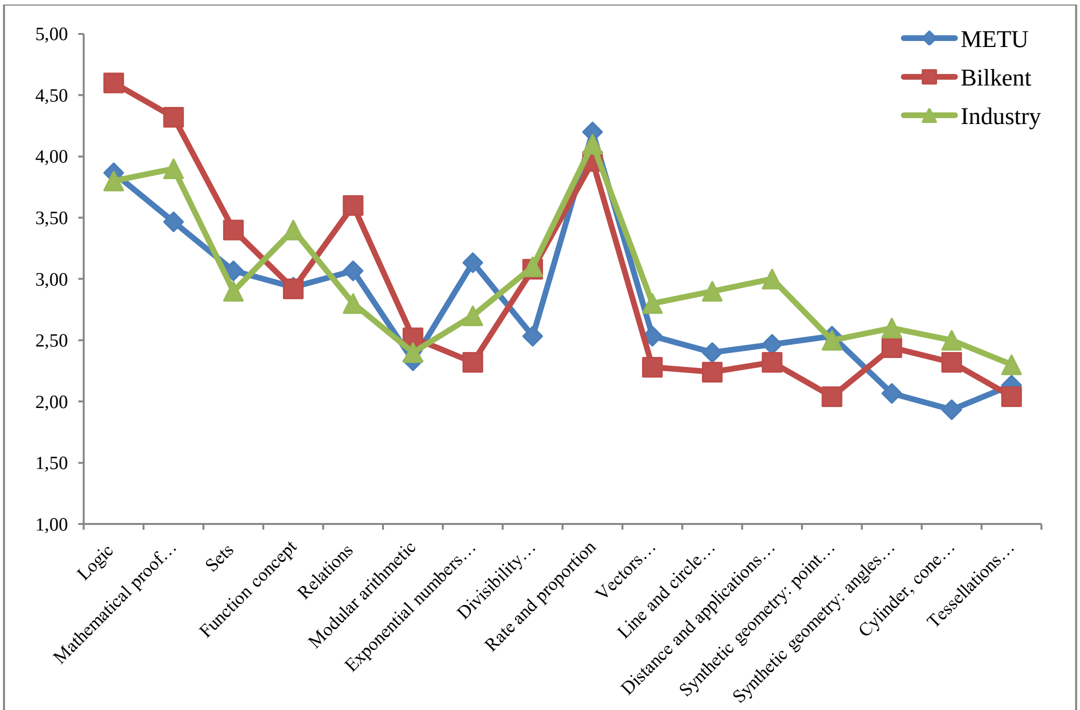

Figure 3. Means of 9th grade mathematics topics across the institutions

According to figure, logic, mathematical proof methods, rate and proportions were found as important for all institutions. Moreover, sets and relations were important topics for both METU and Bilkent University, but not the industry. As exponential numbers and surds were important for only METU, function concept was an important topic for the industry. Furthermore, divisibility was found an important topic for Bilkent University and the industry. However, modular arithmetic, vectors, line and circle properties, distance and its applications, both of synthetic geometries, cylinder, cone and other geometric shapes' properties and tessellations were non-important topics for all institutions.

Differences between the institutions

A variety of One-Way ANOVAs were conducted to investigate mean differences of the importance levels of the 9th grade topics by different institutions (METU, Bilkent and Industry). Table 6 shows the results of the One-Way ANOVA analyses.

Table 6
Results of ANOVA for 9th grade mathematics topics across the institutions

Topic		Sum of Squares	df	Mean Square	F	Sig.
Logic	Between	7.25	2	3.62	3.50	.04
	Within	49.33	47	1.05		
Mathematical proof methods	Between	6.91	2	3.45	4.50	.02
	Within	36.07	47	0.77		
Relations	Between	5.55	2	2.77	2.60	.09
	Within	50.53	47	1.08		
Sets	Between	2.17	2	1.08	0.90	.42
	Within	57.83	47	1.23		
Function concept	Between	1.81	2	0.90	0.70	.51
	Within	61.17	47	1.30		
Modular arithmetic	Between	0.35	2	0.17	0.10	.88
	Within	63.97	47	1.36		
Exponential numbers and surds	Between	6.25	2	3.12	2.10	.14
	Within	71.27	47	1.52		
Divisibility in whole numbers	Between	3.21	2	1.60	0.90	.41
	Within	82.47	47	1.76		
Rate and proportion	Between	0.56	2	0.28	0.30	.76
	Within	48.26	47	1.03		
Vectors in analytic plane…	Between	2.05	2	1.02	0.60	.56
	Within	82.37	47	1.75		
Line and circle properties…	Between	3.12	2	1.56	0.90	.41
	Within	81.06	47	1.73		
Distance and applications…	Between	3.33	2	1.66	1.00	.38
	Within	79.17	47	1.69		
Synthetic geometry: Point, line…	Between	2.89	2	1.44	1.20	.30
	Within	55.19	47	1.17		
Synthetic geometry: Angles…	Between	2.03	2	1.01	0.70	.50
	Within	67.49	47	1.44		
Cylinder, cone, sphere, prism…	Between	2.25	2	1.12	0.70	.52
	Within	78.87	47	1.68		
Tessellations on the plane	Between	0.49	2	0.24	0.20	.82
	Within	58.79	47	1.25		

Based on the results of One-Way ANOVAs, significant mean differences were found for the topics logic $F(2, 47) = 3.45$, $p = .04$, mathematical proof methods $F(2, 47) = 4.45$, $p = .02$. Other topics which were sets, exponential numbers and surds, function concept, relations, modular arithmetic, divisibility of integers, rate and proportion, vectors in analytic plane, operations and applications of vectors, line and circle properties in the analytic plane, distance and applications in the analytic plane, synthetic geometry: point, line, angle, ray, plane, space, synthetic geometry: angles and areas of triangles and polygons, cylinder, cone, sphere, prism, pyramid, and properties of pyramid and tessellations on the plane had no significant mean difference was found ($p > .05$).

To have deeper understanding about sources of the mean differences among the institutions, Post-Hoc analyses were conducted for the topics logic and mathematical proof methods on which significant differences were found. These two topics were only found to be statistically different between Bilkent University and METU. All in all, Bilkent University gave more importance than METU to logic and mathematical proof methods. Thus, other 14 mathematics topics for 9th grade were not found any significant mean difference among institutions.

Table 7
Results of Post-Hoc tests for 9th grade mathematics topics across the institutions

Topic	Post-Hoc Test Used	Institution (i)	Institution (j)	Mean Difference (i-j)
Logic	LSD	METU	Bilkent	-0.73(*)
			Industry	0.07
		Bilkent	METU	0.73(*)
			Industry	.80(*)
		Industry	METU	-0.07
			Bilkent	-.80(*)
Mathematical proof methods	Dunnett C	METU	Bilkent	-.85(*)
			Industry	-0.43
		Bilkent	METU	0.85(*)
			Industry	0.42
		Industry	METU	0.43
			Bilkent	-0.42

* The mean difference is significant at the .05 level.

10th grade mathematics topics

Importance levels of 10th grade mathematics topics for the departments

Important topics and non-important topics for 10th grade among departments were specified through the mean scores. According to Figure 4, the only topic which had means greater than 3.00 was quadratic equations and functions for psychology and law. All other six mathematics topics had means less than 3.00, meaning those topics were not important for any of three departments.

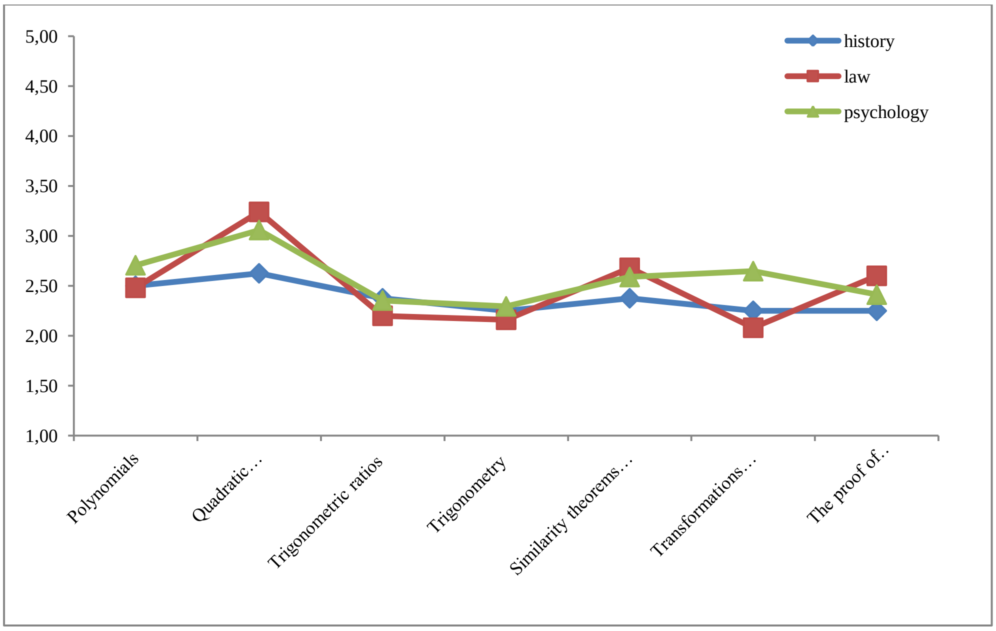

Figure 4. Means of 10th grade mathematics topics across the departments

Differences between the departments

The same process for 9th topics was conducted for the 10th topics. First of all, all 10th grade level including seven mathematics topics were investigated several One-Way ANOVAs. According to the results of One-Way ANOVAs conducted for each of the topics, there is no significant mean difference between departments. So, there is no need to analyze any Post-Hoc analysis.

Table 8
Results of ANOVA for 10th grade mathematics topics across the departments

Topic	Sum of Squares	df	Mean Square	F	Sig.
Polynomials	0.55	2	0.28	0.2	.82
	63.77	47	1.36		
Quadratic equations…	2.3	2	1.15	0.72	.49
	75.38	47	1.6		
Trigonometric ratios	0.32	2	0.16	0.12	.89
	61.76	47	1.31		
Trigonometry	0.19	2	0.1	0.08	.93
	58.39	47	1.24		
Similarity theorems…	0.57	2	0.28	0.17	.84
	77.43	47	1.65		
Transformations…	3.28	2	1.64	1.18	.32
	65.22	47	1.39		
The proof of theorems…	0.86	2	0.43	0.26	.78
	79.62	47	1.69		

Importance levels of 10th grade mathematics topics for the institutions

Mean scores of 10th grade mathematics topics were examined to determine which one was an important topic. The only topic, quadratic equations and functions, was important for Bilkent University and the industry since they had means greater than 3.00. Mean scores can be easily seen from the Figure 5 below.

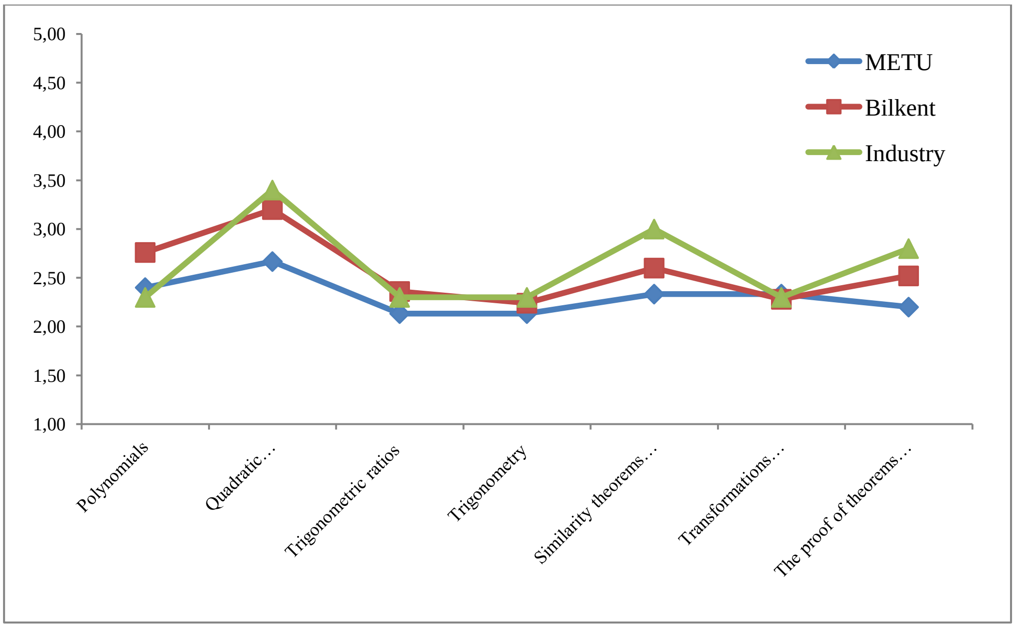

Figure 5. Means of 10th grade mathematics topics across the institutions

Differences between the institutions

When the results One-Way ANOVAs were examined by p-values, there is no significant mean difference between departments (*p*>.05). As a result of this, there is no need to conduct any Post-Hoc analysis.

Table 9
Results of ANOVA for 10th grade mathematics topics across the institutions

Topic		Sum of Squares	df	Mean Square	F	Sig.
Quadratic equations…	Between	3.95	2	1.97	1.26	.29
	Within	73.73	47	1.57		
Trigonometric ratios	Between	0.49	2	0.24	0.19	.83
	Within	61.59	47	1.31		
Trigonometry…	Between	0.19	2	0.09	0.08	.93
	Within	58.39	47	1.24		
Polynomials	Between	2.06	2	1.03	0.78	.47
	Within	62.26	47	1.33		
Similarity theorems…	Between	2.67	2	1.33	0.83	.44
	Within	75.33	47	1.6		
Transformations…	Between	0.03	2	0.01	0.01	.99
	Within	68.47	47	1.46		
The proof of theorems…	Between	2.24	2	1.12	0.67	.52
	Within	78.24	47	1.67		

11th grade mathematics topics

Importance levels of 11th grade mathematics topics for the departments

Topics basic probability concepts, and proof by induction and proof methods, statistics - data presentation, statistics - central tendency and dispersion were important for law, history, and psychology. Counting methods (permutation and combination) were important for law and psychology departments. Additionally, sequences and linear equation systems were important for only psychology department. Other topics Pascal’s triangle and Binomial expansion, complex numbers, exponential equations and functions, logarithmic equations and functions, natural logarithm, matrices, matrices operations and determinants, analytical investigation of conics, circular region and area of circular region, the angles of a circle, circumference of a circle had means less than 3.00 meaning no importance for any department. Besides, these importance levels can be seen through a mean figure below.

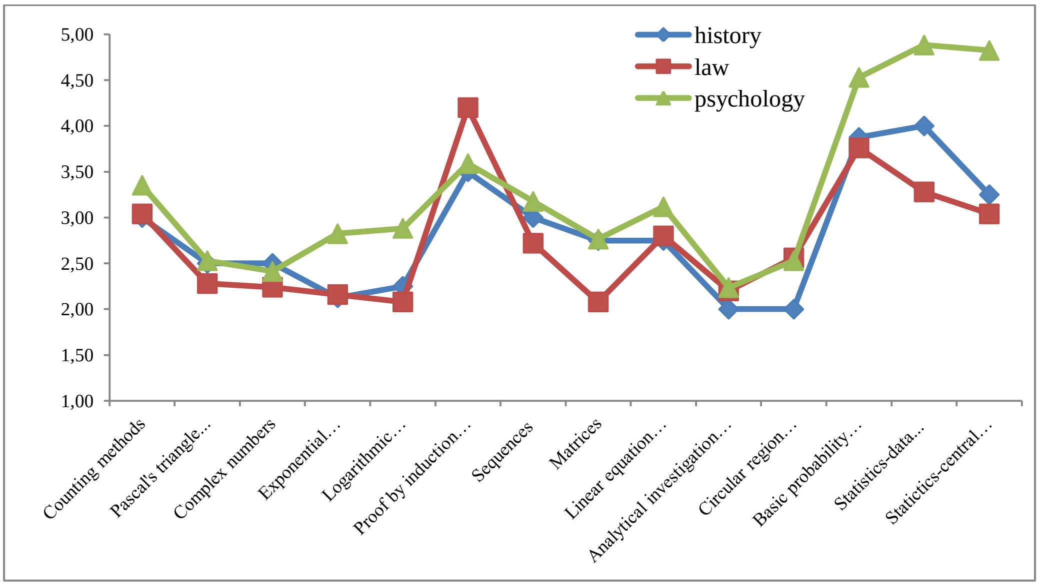

Figure 6. Means of 11th grade mathematics topics across the departments

Differences between the departments

Significant mean differences were found for the topics basic probability concepts $F(2, 47) = 4.12$, $p = .02$, statistics - data notation $F(2, 47) = 12.03$, $p = .00$, statistics - central tendency and dispersion $F(2, 47) = 11.57$, $p = .00$. For the topics complex numbers, exponential equations and functions, logarithmic equations and functions, natural logarithm, proof by induction and proof methods, sequences, matrices, matrices operations and determinants, linear equation systems and applications, counting methods, Pascal's triangle and Binomial formula, analytical investigation of conics, circular region and area of circular region, the angles of a circle, circumference of a circle no significant mean difference was found.

Table 10
Results of ANOVA for 11th grade mathematics topics across the departments

Topic		Sum of Squares	df	Mean Square	F	Sig.
Complex numbers	Between	0.54	2	0.27	0.20	.82
	Within	64.68	47	1.38		
Exponential equations…	Between	5.07	2	2.54	1.90	.16
	Within	62.71	47	1.33		
Logarithmic equations…	Between	6.68	2	3.34	2.75	.07
	Within	57.11	47	1.22		
Proof by induction…	Between	5.16	2	2.58	2.16	.13
	Within	56.12	47	1.19		
Sequences	Between	2.17	2	1.09	0.80	.45
	Within	63.51	47	1.35		
Matrices…	Between	5.78	2	2.89	1.93	.16
	Within	70.40	47	1.50		
Linear equation systems…	Between	1.24	2	0.62	0.40	.68
	Within	73.27	47	1.56		
Counting methods	Between	1.18	2	0.59	0.39	.68
	Within	70.84	47	1.51		
Pascal's triangle…	Between	0.73	2	0.36	0.25	.78
	Within	69.28	47	1.47		
Analytical investigation of conics	Between	0.32	2	0.16	0.11	.89
	Within	67.06	47	1.43		
Circular region and area…	Between	2.03	2	1.01	0.56	.57
	Within	84.4	47	1.80		
Basic probability concepts	Between	6.25	2	3.13	4.12	.02
	Within	35.67	47	0.76		
Statistics - data notation	Between	26.02	2	13.01	12.03	.00
	Within	50.81	47	1.08		
Statistics - central tendency…	Between	33.95	2	16.98	11.57	.00
	Within	68.93	47	1.47		

Post-Hoc analyses were needed to specify topics on which significant differences were found. For the topic statistics - data notation (i) history and psychology and (ii) law and psychology were found to be statistically different. However, the topic for psychology was more important than both history and law. For the topic statistics - central tendency and dispersion, significant difference was only found between law and psychology, but psychology department gave more importance than law. Similarly, basic probability concepts were found statistically different among law and psychology, in which psychology had higher importance level than law.

Table 11
Results of Post-Hoc tests for 11th grade mathematics across the departments

Topic	Post-Hoc Test Used	Department (i)	Department (j)	Mean Difference (i-j)
Basic probability concepts	LSD	History	Law	0.16
			Psychology	-0.65
		Law	History	-0.16
			Psychology	-0.77(*)
		Psychology	History	0.65
			Law	0.77(*)
Statistics - data notation	Dunnett C	History	Law	0.72
			Psychology	-0.88(*)
		Law	History	-0.72
			Psychology	-1.60(*)
		Psychology	History	0.88(*)
			Law	1.60(*)
Statistics – central tendency…	Dunnett C	History	Law	0.21
			Psychology	-1.57
		Law	History	-0.21
			Psychology	-1.78(*)
		Psychology	History	1.57
			Law	1.78(*)

* The mean difference is significant at the .05 level.

Importance levels of 11th grade mathematics topics for the institutions

Considering mean scores of 11th grade mathematics topics according to institutions, proof by induction and proof methods, counting methods, basic probability concepts, statistics-data notation, and statistics-central tendency and dispersion were important topics for all three institutions. Furthermore, the linear equation systems and applications were the only important topic for the industry. Besides, complex numbers, exponential equations and functions, logarithmic equations and functions, natural logarithm, sequences, matrices, matrices operations and determinants, Pascal’s triangle and Binomial formula, analytical investigation of conics, circular region and area of circular region, the angles of a circle, circumference of a circle were not found to be important.

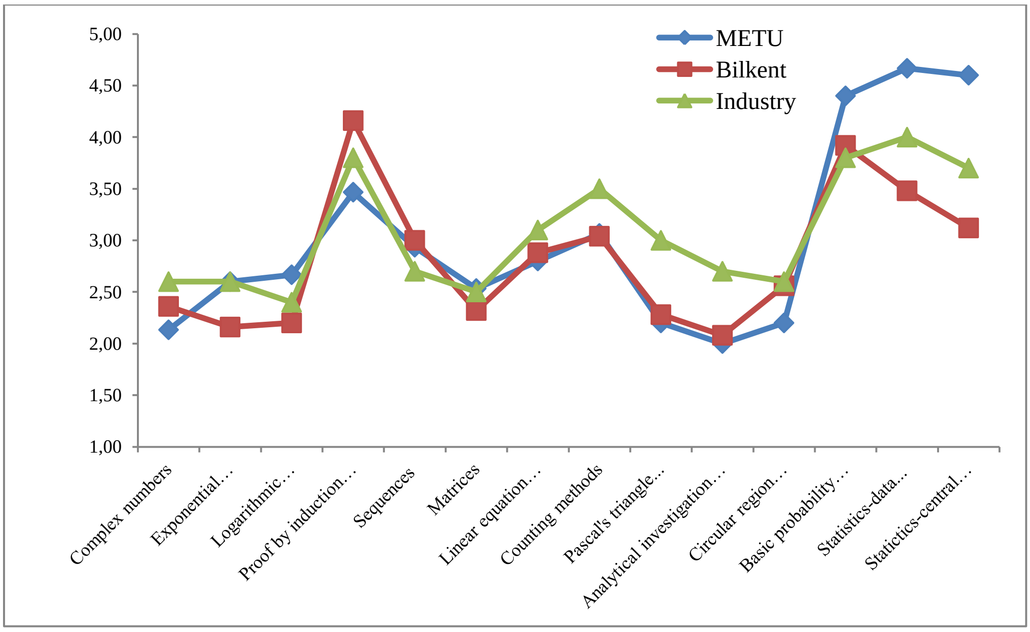

Figure 7. Means of 11th grade mathematics topics across the institutions

Differences between the institutions

Several One-Way ANOVAs were conducted to find out differences between institutions. According to the results, significant mean differences were found for only two topics which were statistics - data notation $F(2, 47) = 4.897$, $p = .01$, and statistics - central tendency and dispersion, $F(2, 47) = 5.86$, $p = .01$. However, for the topics basic probability concepts, complex numbers, exponential equations and functions, logarithmic equations and functions, natural logarithm, proof by induction and proof methods, sequences, matrices, matrices operations and determinants, linear equation systems and applications, counting methods, Pascal's triangle and Binomial formula, analytical investigation of conics, circular region and area of circular region, the angles of a circle , circumference of a circle no significant mean difference was found.

Table 12
Results of ANOVA for 11th grade mathematics topics across the institutions

Topic		Sum of	df	Mean	F	Sig.
Complex numbers	Between Groups	1.33	2.00	0.66	0.49	.62
	Within Groups	63.89	47.00	1.36		
Exponential equations…	Between Groups	2.42	2.00	1.21	0.87	.43
	Within Groups	65.36	47.00	1.39		
Logarithmic equations…	Between Groups	2.05	2.00	1.02	0.78	.47
	Within Groups	61.73	47.00	1.31		
Proof by induction…	Between Groups	4.59	2.00	2.29	1.90	.16
	Within Groups	56.69	47.00	1.21		
Sequences	Between Groups	0.65	2.00	0.32	0.23	.79
	Within Groups	65.03	47.00	1.38		
Matrices…	Between Groups	0.51	2.00	0.25	0.16	.86
	Within Groups	75.67	47.00	1.61		
Linear equation systems…	Between Groups	0.56	2.00	0.28	0.18	.84
	Within Groups	73.94	47.00	1.57		
Counting methods	Between Groups	1.63	2.00	0.81	0.54	.59
	Within Groups	70.39	47.00	1.50		
Pascal's triangle…	Between Groups	4.56	2.00	2.28	1.64	.21
	Within Groups	65.44	47.00	1.39		
Analytical investigation of conics	Between Groups	3.44	2.00	1.72	1.26	.29
	Within Groups	63.94	47.00	1.36		
Circular region and area...	Between Groups	1.46	2.00	0.73	0.40	.67
	Within Groups	84.96	47.00	1.81		
Basic probability concepts	Between Groups	2.88	2.00	1.44	1.73	.19
	Within Groups	39.04	47.00	0.83		
Statistics - data notation	Between Groups	13.25	2.00	6.62	4.90	.01
	Within Groups	63.57	47.00	1.35		
Statistics - central tendency…	Between Groups	20.54	2.00	10.27	5.86	.01
	Within Groups	82.34	47.00	1.75		

Similarly, topics which had significant mean differences were needed to further investigate sources of the mean differences among the institutions through Post-Hoc analyses. Thus, topics statistics - data notation and statistics - central tendency and dispersion were only found significant difference between Bilkent University and METU. Both of topics had higher importance mean levels of METU than Bilkent University's.

Table 13
Results of Post-Hoc tests for 11th grade mathematics topics across the institutions

Topic	Post-Hoc Test Used	Institution (i)	Institution (j)	Mean Difference (i-j)
Statistics – data notation	Dunnett C	METU	Bilkent	1.19(*)
			Industry	0.67
		Bilkent	METU	-1.19(*)
			Industry	-0.52
		Industry	METU	-0.67
			Bilkent	0.52
Statistics - central tendency…	Dunnett C	METU	Bilkent	1.48(*)
			Industry	0.90
		Bilkent	METU	-1.48(*)
			Industry	-0.58
		Industry	METU	-0.90
			Bilkent	00.58

* The mean difference is significant at the .05 level.

12th grade mathematics topics

Importance levels of 12th grade mathematics topics for the departments

It was analyzed that there was only one topic, drawing and interpreting function graphs, as important for history and psychology. Limit and continuity, derivatives and applications, integration, vectors in space, and plane in space were specified as non-important topics among 12th grade mathematics topics for the departments.

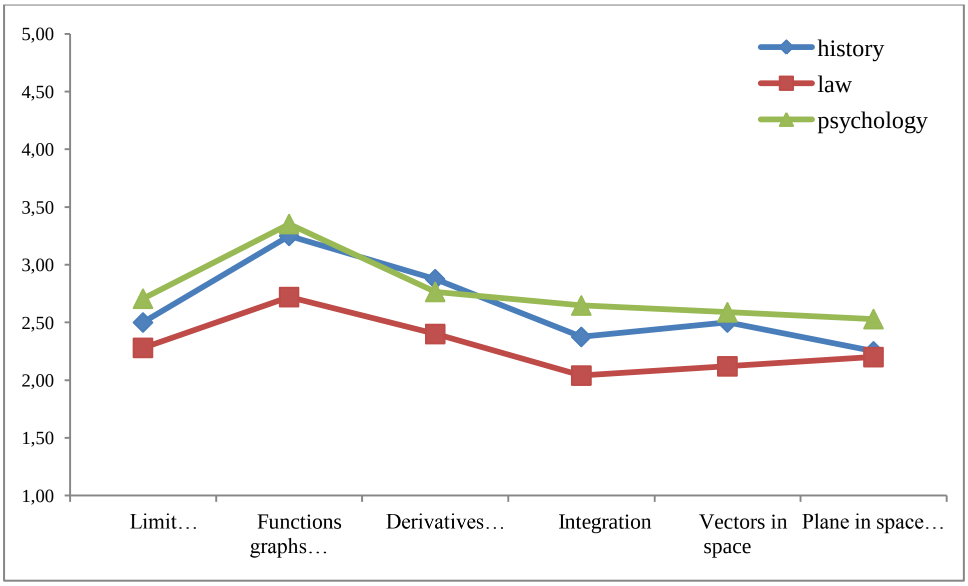

Figure 8. Means of 12th grade mathematics topics across the departments

Differences between the departments

All 12th grade mathematics topics were examined to specify mean differences between departments, but there is no significant mean difference between departments based on One-Way ANOVAs ($p > .05$). Therefore, there was no need to further investigation by any Post-Hoc analysis.

Table 14
Results of ANOVA for 12th grade mathematics topics across the departments

Topic		Sum of Squares	df	Mean Square	F	Sig,
Limit and continuity	Between	1.85	2	0.93	0.70	.50
	Within	62.57	47	1.33		
Drawing and interpreting…	Between	4.56	2	2.28	1.4	.26
	Within	76.42	47	1.63		
Derivatives…	Between	2.07	2	1.03	0.66	.52
	Within	73.93	47	1.57		
Integration	Between	3.78	2	1.89	1.19	.31
	Within	74.72	47	1.59		
Vectors…	Between	2.46	2	1.23	0.82	.45
	Within	70.76	47	1.51		
Plane in space…	Between	1.15	2	0.57	0.44	.65
	Within	61.74	47	1.31		

Importance levels of 12th grade mathematics topics for the institutions

There was only one topic which was important for just the industry. Drawing and interpreting function graphs had the mean score greater than 3.00 for the industry. Other five topics of 12th grade were non-important for all the institutions.

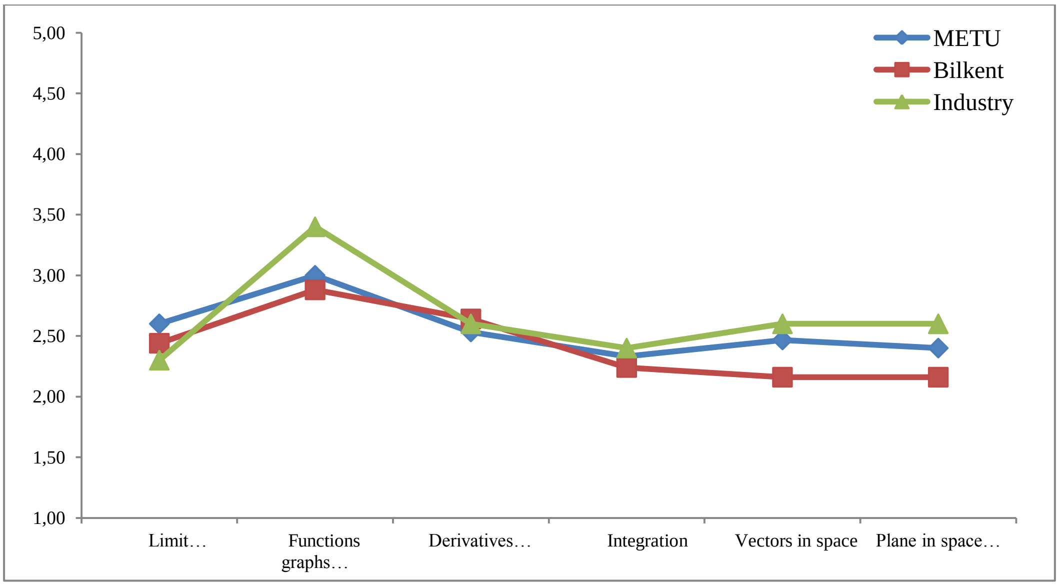

Figure 9. Means of 12th grade mathematics topics across the institutions

Differences between the institutions

Similar to results of differences between departments for 12th topics, there is no significant mean difference between institutions as well. So, any Post-Hoc analysis was not conducted.

Table 15
Results of ANOVA for 12th grade mathematics topics across the institutions

Topic		Sum of Squares	df	Mean Square	F	Sig.
Limit and continuity	Between	0.56	2	0.28	.21	.82
	Within	63.86	47	1.36		
Drawing and interpreting…	Between	1.94	2	0.97	.58	.57
	Within	79.04	47	1.68		
Derivatives…	Between	0.11	2	0.05	.03	.97
	Within	75.89	47	1.62		
Integration	Between	0.21	2	0.10	.06	.94
	Within	78.29	47	1.67		
Vectors…	Between	1.73	2	0.86	.57	.57
	Within	71.49	47	1.52		
Plane in space…	Between	1.52	2	0.76	.58	.56
	Within	61.36	47	1.31		

IBDP curricula mathematics topics

Importance levels of IBDP curricula mathematics topics for the departments

Finite random variables and Bayes' theorem were important for psychology department.

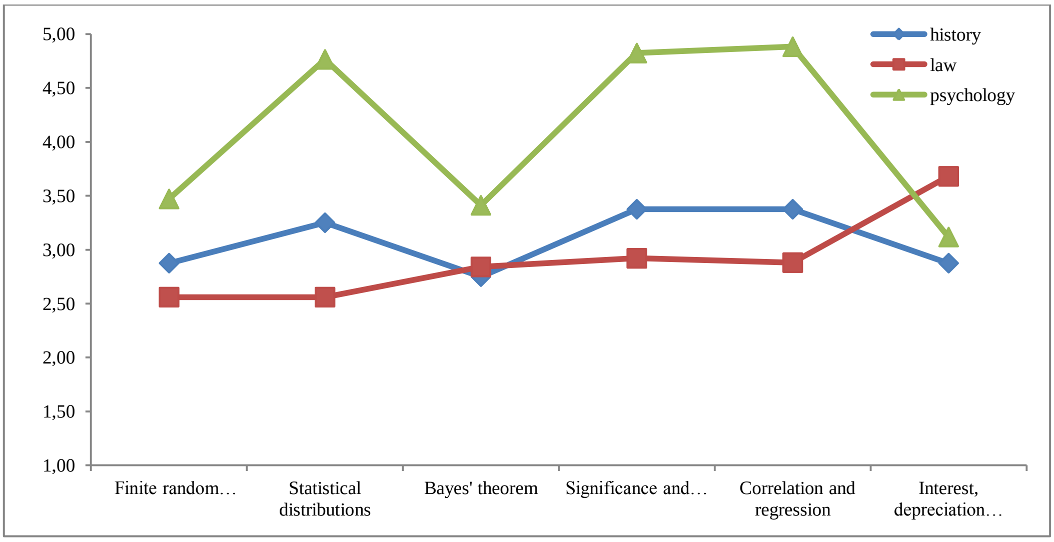

Figure 10. Means of mathematics topics in IBDP across the departments

Statistical distributions, significance and hypothesis testing, correlation and regression were important both psychology and history departments. However, as can be seen from the Figure 10, psychology department had higher importance levels than history department. Interest, depreciation and cost are important both law and psychology, but this time law had a higher importance level than psychology.

Differences between the departments

When the differences between departments were investigated by One- Way ANOVAs, the results pointed out that there were significant mean differences for the topics statistical distribution $F(2, 47) = 23.86$, $p = .00$, significance and hypothesis testing $F(2, 47) = 18.10$, $p = .00$, and correlation and regression $F(2, 47) = 20.94$, *p* = .00. Other topics finite random variables, Bayes' theorem, and interest, depreciation and cost had no significant mean difference was found.

Table 16
Results of ANOVA in IBDP mathematics topics across the departments

Topic		Sum of Squares	df	Mean Square	F	Sig.
Finite random variables	Between	8.41	2	4.21	2.77	.07
	Within	71.27	47	1.52		
Statistical distribution	Between	49.46	2	24.73	23.86	.00
	Within	48.72	47	1.04		
Bayes' theorem	Between	4.00	2	2.00	2.00	.15
	Within	46.98	47	1.00		
Significance and hypothesis…	Between	37.33	2	18.67	19.00	.00
	Within	46.19	47	.98		
Correlation and regression	Between	41.24	2	20.62	20.94	.00
	Within	46.28	47	.99		
Interest, depreciation and cost	Between	5.44	2	2.72	1.64	.21
	Within	78.08	47	1.66		

Since Post-Hoc analyses were needed to find out among which topics had different means, three topics were tested by Dunnet's C. All in all, statistical distribution, significance and hypothesis testing, and correlation and regression had a similar type of significant mean difference among institutions as (i) psychology and history (ii) psychology and law. That is, statistical distribution was more important topic for psychology than history, but not important for law. Typically, significance and hypothesis testing was more important topic for psychology than history, but not important for law. Furthermore, correlation and regression was more important topic for psychology than history, but not important for law, too.

Table 17
Results of Post-Hoc tests in IBDP mathematics topics across the departments

Topic	Post-Hoc Test Used	Department (i)	Department (j)	Mean Difference (i-j)
Statistical distribution	Dunnett C	History	Law	0.69
			Psychology	-1.51(*)
		Law	History	-0.69
			Psychology	-2.20(*)
		Psychology	History	1.51(*)
			Law	2.20(*)
Significance and hypothesis…	Dunnett C	History	Law	0.46
			Psychology	-1.45(*)
		Law	History	-0.46
			Psychology	-1.90 (*)
		Psychology	History	1.45(*)
			Law	1.90(*)
Correlation and regression	Dunnett C	History	Law	0.50
			Psychology	-1.51(*)
		Law	History	-0.50
			Psychology	-2.00(*)
		Psychology	History	1.51(*)
			Law	2.00(*)

* The mean difference is significant at the .05 level.

Importance levels of IBDP curricula mathematics topics for the institutions

Interest, depreciation, and cost were important for all the institutions. Significance and hypothesis testing and correlation and regression were important for both METU and Bilkent University. Finite random variables, statistical distributions and Bayes' theorem were important for only METU.

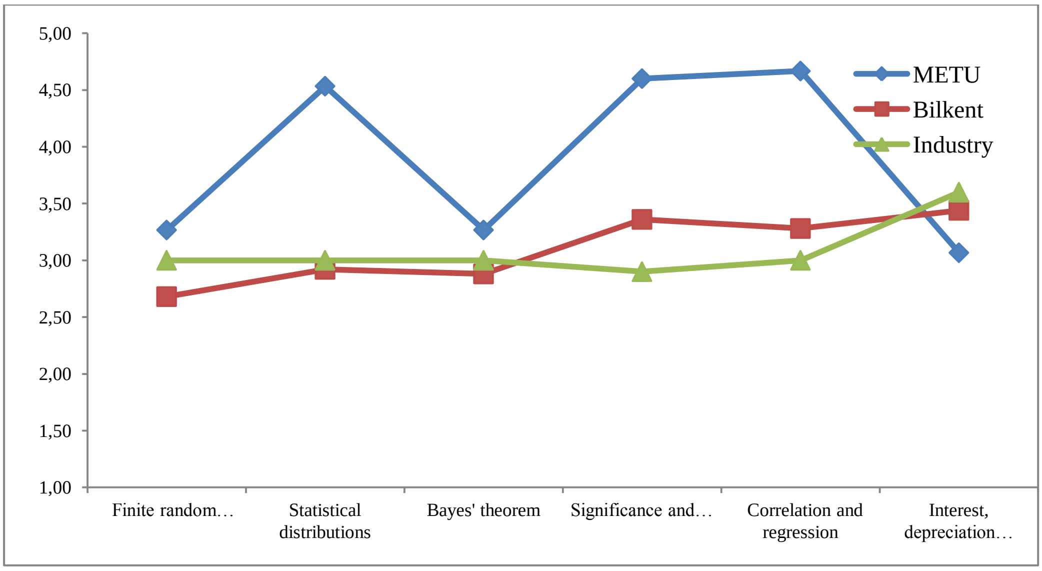

Figure 11. Means of mathematics topics in IBDP across the institutions

Differences between the institutions

According to the results, significant mean differences were found for the topics statistical distribution $F(2, 47) = 8.74$, $p = .00$, significance and hypothesis testing $F(2, 47) = 8.03$, $p = .00$, correlation and regression $F(2, 47) = 8.45$, $p = .00$. For the topics finite random variables, Bayes' theorem, and interest, depreciation and cost no significant mean difference was found.

Table 18
Results of ANOVA for IBDP mathematics topics across the institutions

Topic		Sum of Squares	df	Mean Square	F	Sig.
Finite random variables	Between	3.31	2	1.65	1.02	.37
	Within	76.37	47	1.63		
Statistical distribution	Between	26.61	2	13.30	8.74	.00
	Within	71.57	47	1.52		
Bayes' theorem	Between	1.41	2	.70	0.67	.52
	Within	49.57	47	1.06		
Significance and hypothesis…	Between	21.26	2	10.63	8.03	.00
	Within	62.26	47	1.33		
Correlation and regression	Between	23.15	2	11.57	8.45	.00
	Within	64.37	47	1.37		
Interest, depreciation and cost	Between	2.03	2	1.01	0.58	.56
	Within	81.49	47	1.73		

According to Post-Hoc analysis, statistical distribution, significance and hypothesis testing and correlation and regression were found to be statistically significant different as (i) METU and Bilkent University and (ii) METU and Industry. For the statistical distribution, it was important statistically for METU, but not important for Bilkent University and the industry. Significance and hypothesis testing for METU was significantly more important than Bilkent University, but it was not important for the industry though it was important for METU. Correlation and regression had same relation among institutions like significance and hypothesis testing.

Table 19
Results of Post-Hoc tests for IBDP mathematics topics across the institutions

Topic	Post-Hoc Test Used	Institution(i)	Institution (j)	Mean Difference (i-j)
Statistical distribution	Dunnett C	METU	Bilkent	1.61(*)
			Industry	1.53(*)
		Bilkent	METU	-1.61(*)
			Industry	-0.08
		Industry	METU	-1,53(*)
			Bilkent	0.08
Significance and hypothesis…	LSD	METU	Bilkent	1.24(*)
			Industry	1.70(*)
		Bilkent	METU	-1.24(*)
			Industry	.46
		Industry	METU	-1.70(*)
			Bilkent	-0.46
Correlation and regression	LSD	METU	Bilkent	1.39(*)
			Industry	1.67(*)
		Bilkent	METU	-1.39(*)
			Industry	.28
		Industry	METU	-1.67(*)
			Bilkent	-0.28

* The mean difference is significant at the .05 level.

Mathematical skills

Importance levels of mathematical skills for the departments

As can be seen from the Figure 12 below, all mathematical skills had importance levels greater than 3.00, so all mathematical skills were important for the departments.

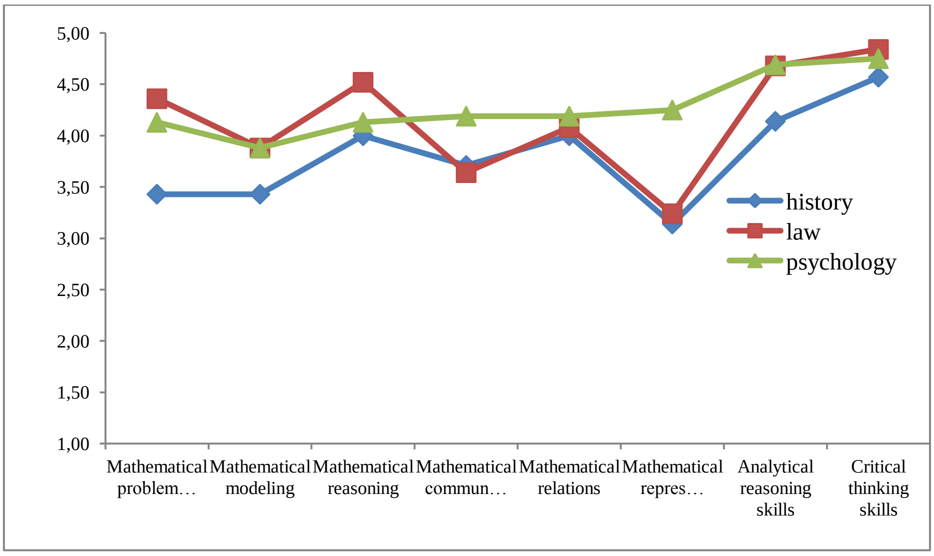

Figure 12. Means of mathematical skills for the departments

Differences between departments

Mathematical problem solving $F(2, 45) = 3.93$, $p = .03$ and mathematical representations $F(2, 45) = 4.24$, $p = .02$ had meaningful mean differences.

Table 20
Results of ANOVA for mathematical skills across the departments

Skill		Sum of Squares	df	Mean Square	F	Sig.
Mathematical problem solving	Between	4.76	2	2.38	3.93	.03
	Within	27.22	45	0.61		
Mathematical modelling	Between	1.21	2	0.60	0.71	.50
	Within	38.10	45	0.85		
Mathematical reasoning	Between	2.32	2	1.16	1.87	.17
	Within	27.99	45	0.62		
Mathematical communication	Between	3.04	2	1.52	1.23	.30
	Within	55.63	45	1.24		
Mathematical relations	Between	0.20	2	0.10	0.09	.91
	Within	50.28	45	1.12		
Mathematical representations	Between	11.40	2	5.70	4.24	.02
	Within	60.42	45	1.34		
Analytical reasoning skills	Between	1.75	2	0.87	1.99	.15
	Within	19.74	45	0.44		
Critical thinking skills	Between	0.41	2	0.20	0.75	.48
	Within	12.07	45	0.27		

There was no significant mean difference found for the skills mathematical modelling, mathematical reasoning, mathematical communication, mathematical relations, analytical reasoning skills, and critical thinking skills.

For further investigation of skills, which had significant mean differences, were applied the Post-Hoc analyses. The significant mean differences were between law and history found for mathematical problem solving skill. Law had a higher importance level than history. Other significant mean differences were between (i) psychology and history, and (ii) psychology and law for mathematical representations. The importance level of psychology was higher than law and history.

Table 21
Results of Post-Hoc tests for mathematical skills across the departments

Skill	Post-Hoc Test Used	Department (i)	Department (j)	Mean Difference (i-j)
Mathematical problem solving	LSD	History	Law	-0.93(*)
			Psychology	-0.70
		Law	History	0.93(*)
			Psychology	0.24
		Psychology	History	0.70
			Law	-0.24
Mathematical representations	LSD	History	Law	-0.10
			Psychology	-1.11(*)
		Law	History	0.10
			Psychology	-1.01(*)
		Psychology	History	1.11(*)
			Law	1.01(*)

* The mean difference is significant at the .05 level.

Importance levels of mathematical skills for the institutions

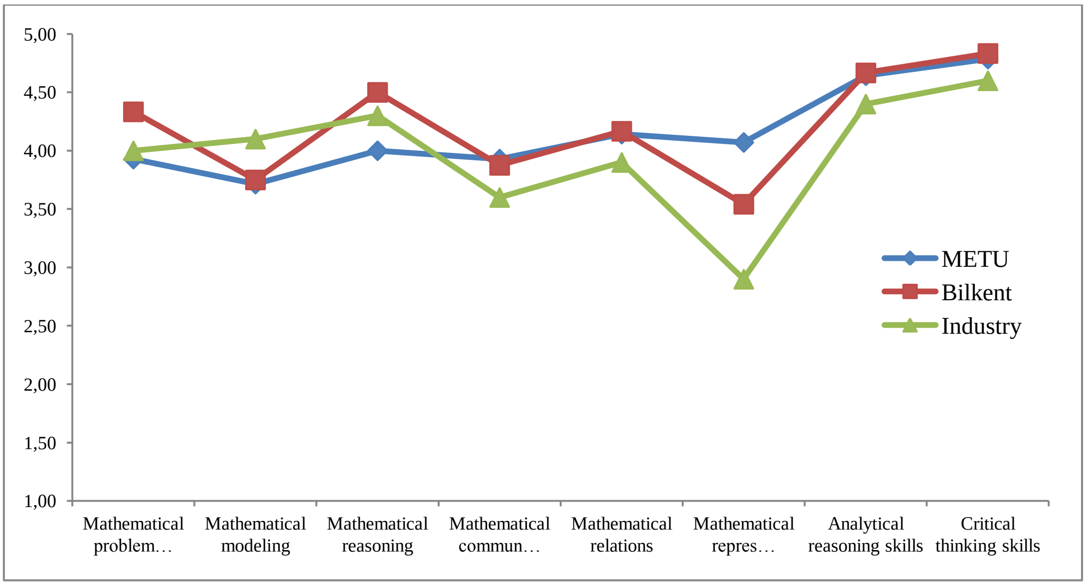

Figure 13. Means of mathematical skills for the institutions

As can be seen from the Figure 13, all mathematical skills except mathematical representation skill had importance levels greater than 3.00, so all mathematical skills except the one were important for the institutions. Mathematical representation skill was found to be non-important for the industry.

Differences between the institutions

There was no significant mean difference between the institutions. Table 22 shows the results of mathematical skills across Bilkent, METU and industry.

Table 22
Results of ANOVA for mathematical skills across the institutions

Skill		Sum of Squares	df	Mean Square	F	Sig.
Mathematical problem solving	Between	1.72	2	.86	1.28	.29
	Within	30.26	45	.67		
Mathematical modelling	Between	1.06	2	.53	.62	.54
	Within	38.26	45	.85		
Mathematical reasoning	Between	2.21	2	1.11	1.77	.18
	Within	28.10	45	.62		
Mathematical communication	Between	.71	2	.36	.28	.76
	Within	57.95	45	1.29		
Mathematical relations	Between	.53	2	.27	.24	.79
	Within	49.95	45	1.11		
Mathematical representations	Between	8.03	2	4.01	2.83	.07
	Within	63.79	45	1.42		
Analytical reasoning skills	Between	.53	2	.27	.57	.57
	Within	20.95	45	.47		
Critical thinking skills	Between	.39	2	.19	.72	.49
	Within	12.09	45	.27		

As can be seen from the Table 22, there was no need to apply any Post- Hoc analysis because there was no significant mean difference.

CHAPTER 5: DISCUSSION

Introduction

The study investigated mathematics topics and skills for high school students, who will study in law, psychology, or history departments at university in the future. That is, the present study aimed to answer these research questions: ‘Which topics and skills should be included in high school mathematics curriculum based on importance levels of the topics, for better preparation of high school students for university education in social sciences?’, ‘Do the social science departments differ in importance levels given for mathematics topics and skills obtained in high school?’ and ‘Do the different institutions (universities and industry) related to social sciences differ in importance levels given for mathematics topics and skills obtained in high school?’ The discussion of findings is organized according to following outline:

1. Discussion with respect to departments
2. Discussion with respect to institutions
3. Mathematical skills
4. Implication for practice
5. Implication for research
6. Limitations

Discussion with respect to the departments

Mathematics topics

According to findings of the study, 9^{th} grade topics are generally important for social science departments except modular arithmetic and divisibility of integers. However, function concept and exponential numbers and surds are important for particular departments. 9^{th} grade mathematics curriculum can be differentiated in terms of teaching function concept (law and psychology) and exponential numbers and surds (psychology) to different departments. On the other hand, logic and mathematical proof methods have higher importance levels of law than history and psychology. So, students who will study in law for future education can need more learning hours for these two topics. This is consistent with previous finding which claimed that logic is important for all students (Atlıhan & Konur, 2012). Moreover, the importance of sets for law is consistent with the findings of Can (2005) which assert set concept makes mathematics and law close up and has a relationship with law in technical way. Also, teaching mathematical proof methods for law are supported by Can (2005) with respect to the use of mathematical analyses to be able to define assumptions, propositions and reasoning in any legal case. Since 9^{th} grade geometry topics were considered as non-important for all departments, there is no differentiation among departments. The previous studies (Gamoran & Hannigan, 2000) explain the situation by shaping curriculum for 9^{th} grade students as general math, pre-algebra, algebra, and geometry according to students' interests and future plans for vocational life. Similarly, 9^{th} grade students who will need mathematics rarely tend to choose only general math courses (Tucker & Coddling, 2008). The rare need of geometry courses at social science departments is line with findings of the study (Conley et al., 2011) in which 13 social scientists out of 420 from different universities are considered geometry as important. This situation can be proved when university curriculum programs are examined. For example, the curriculum of social science departments except history department covers statistics, calculus, and computing, economics and finance as related to mathematics (Bilkent, 2013; METU, 2013; Hacettepe, 2013; Öztürk, 2010). Table gives information about important and non-important 9th grade topics according to departments.

Table 23
Important 9th grade mathematics topics across the departments

Logic	LHP
Mathematical proof methods	LHP
Sets	LHP
Relations	LHP
Rate and proportion	LHP
Function Concept	LP
Exponential numbers and surds	P
Divisibility of integers	None
Modular arithmetic	None
Vectors in analytic plane, operations and vectors	None
Cylinder, cone, sphere, prism, pyramid and their properties	None
Synthetic geometry: point, line, angle, ray, plane, space	None
Synthetic geometry: angles and areas of triangles and polygons	None
Line and circle properties in the analytic plane	None
Distance and applications in analytic plane	None
Tessellations on the plane	None

L, H, and P refer to Law, History and Psychology departments, respectively.

Among the seven 10th grade topics, only quadratic equations and functions were reported to be important by law and psychology departments. There is no difference among departments in terms of 10th grade mathematics topics. In other words, 10th grade mathematics topics are not needed for law, history or psychology education at university except quadratics equations and functions. Therefore, students who will study law or psychology can choose this course at 10th grade as an elective course. History department differs from law and psychology at this point. There is no course which is important for history department among 10th grade mathematics topics. These findings have a similarity with GCSE mathematics curriculum since students who study in Foundation Tier do not have any trigonometry and advances geometry

(Lee, 2010). When examined the history curricula of Bilkent University, METU and Hacettepe University, there is no course related to mathematics. Also, research studies show that a few people use algebra 2, trigonometry, calculus and geometry in professional life (Cavanagh, 2007, p. 2).

Table 24
Important 10th grade mathematics topics across the departments

Quadratic equations and functions	LP
Polynomials	None
Trigonometric ratios	None
Trigonometry	None
Similarity theorems for triangles	None
Transformations on the plane	None
The proof of theorems in geometry	None

L, H, and P refer to Law, History and Psychology departments, respectively.

For the 11th grade topics, all statistics topics are important for law, history, and psychology. In the following parts, IBDP statistical topics will also be examined across departments to compare with importance levels of 11th grade national curriculum statistical topics. However, there is a meaningful difference among departments. All statistics topics have higher importance level for psychology. Moreover, proof by induction is important for all three departments. When compared content of curriculum with other countries, induction and complex numbers are not included in Canadian and German high school mathematics curricula (Çetinkaya, Güzel, & Karataş, 2010). In the light of the findings about induction and complex numbers, while covering induction in MoNE might be an advantage of social science students, complex numbers might be a disadvantage for them. The Table 25 shows important the topics and not important topics for each department.

Table 25
Important 11th grade mathematics topics across the departments

Complex numbers	None
Pascal triangle and Binomial formula	None
Exponential equations and functions	None
Logarithmic equations and functions	None
Proof by induction and proof methods	PHL
Sequences	P
Linear equation systems	P
Counting methods	PL
Analytical investigation of conics	None
Circular region and area of circular region, the angles of a circle…	None
Basic probability concepts	PHL
Statistics- data notation	PHL
Statistics- central tendency and dispersion	PHL

L, H, and P refer to Law, History and Psychology departments, respectively.

The only topic drawing and interpreting functions graphs is important for both psychology and history among 12th grade mathematics topics. This is consistent with the findings (Atlıhan & Konur, 2012) which conclude that most of 12th grade topics are advanced mathematical knowledge and topics like limit, derivatives and integration should not be taught to engineer students at university instead of teaching all students in high school. Additionally, researchers state that advanced mathematics for all students does not provide to fit all intended skills (Cavanagh, 2007). Table 26 shows the 12th grade according to their importance among departments.

Table 26
Important 12th grade mathematics topics across the departments

Limit and continuity	None
Drawing and interpreting function concept	PH
Derivatives	None
Integration	None
Vectors	None
Plane in space	None

L, H, and P refer to Law, History and Psychology departments, respectively.

Considering IBDP curricula, there are six topics that MoNE does not include in mathematics high school curriculum. These topics are generally statistics topics. In addition, all IBDP topics are important for psychology. Even if history departments do not have any mathematics courses at university, findings of the study indicated that some statistical topics in IBDP were needed to study in history. Therefore, students who will study in history can choose statistical courses at 12th grade as an elective course. Besides, for the law department IBDP statistical topics seem like as non-important topics even if 11th grade national curriculum statistical topics are important for the law department. So, 11th grade current statistical topics are enough to learn for students who will prefer law department at university.

Table 27
Important IBDP mathematics topics across the departments

Finite random variables	P
Bayes theorem	P
Statistical distribution	PH
Significance and hypothesis testing	PH
Correlation and regression	PH
Interest, depreciation and cost	PL

L, H, and P refer to Law, History and Psychology departments, respectively.

In general, for the 10th, 11th and 12th grade levels, most of the mathematics topics were given lower importance levels. However, only quadratic equations and functions from 10th grade (law and psychology) and drawing and interpreting functions from 12th grade (psychology and history) are considered as important. So, 10th and 12th grades mathematics curriculum can differentiate according to departments and their needs. On the other hand, statistics topics in 11th grade level were considered to be important by almost all departments. All in all, there is no need to teach all students to all mathematics topics (Ernest, 1991). These findings indicate that mathematics education is a tool to use logic, statistics, probability, simulation model in law department with respect to mathematical principles and rules (Balkır & Apaydın, 2011), especially statistics were more important for business, psychology, or social sciences at higher education level than others (Conley et all, 2011; Lee, 2010). As academic disciplines, statistics and probability in Belgium was taught as compulsory in law faculties during nineteenth century, so jurists had known the statistics the most (Ottaviani, 1991, p. 245). In Belgium, also history-students had to take statistics and probability courses in order to have knowledge about a country's economics and politics (François & Bracke, 2006). Moreover, the curriculum of social science departments except history covers statistics, calculus, and computing, economics and finance (Bilkent, 2013; METU, 2013; Hacettepe, 2013; Öztürk 2010). However, Turkish national mathematics curriculum does not have a comprehensive statistics unit in high school (Çetinkaya, Güzel, & Karataş, 2010). Statistics is one course among ten courses that students must take at university. With statistics, psychologists can organize and interpret all data about real life situations (Cherry, 2013).

All in all, according to findings, there is a need to a mathematics curriculum for preparation to social science departments. There are some suggestions of previous studies as:

- MoNE can reduce content of courses (Yanpar & Özer, 2004),
- curriculum can have some particular knowledge or skills which are planned and intended (Cuban,1976),
- mathematics curriculum can prepare students for becoming competent citizens of modern life (or general mathematical skills for life), for getting a job, for helping to understand other disciplines, further university education in social sciences (history, law, sociology, philosophy, etc.) and in some mathematics-related departments such as engineering (Cockcroft, 1982; Updegraff et. al., 1996; Long et.al., 2012),
- curriculum differentiate tracks for those who want to study mathematics related fields such as "mathematics, engineering or information technology", tracks for those who will work in "non-mathematics related work such as the

humanities, or vocational tracks for those who will not go to university (Ernest, 2002).

Moreover, MoNE has been developing mathematics curriculum introducing some changes. With the last changes in high school mathematics curriculum in 2013, 9th and 10th grade students will learn general math. If students prefer to continue with general math for grades 11 and 12, they have a chance to choose general math. Otherwise, they can choose advance mathematics for 11th and 12th grades. It is expected that advance mathematics courses should be preferred by students who want to be scientist, engineer or any job based on mathematics. These changes will be conducted starting from 9th grade students and following years they will be covered by each grade systematically. In the future, it is possible to have a mathematics curriculum which is differentiated by topics need for each department at university.

Mathematical skills

Generally, mathematical skills are important for all departments. This is relevant to PISA mathematical literacy skills which are thinking numerically and spatially, interpreting and critically analyzing the problematic everyday situations. Also, these skills have similarities with 21st century skills as "critical thinking, problem solving, creativity, innovation, initiative and self-direction, leadership, adaptability, and digital media capabilities" in order to adapt educational approaches in the world (Blackboard Institute Staffs, 2004). A report matches up with findings of the study on skills such as solving realistic problems, reasoning abstractly, thinking critically, modeling with mathematics, and using technological tools appropriately (Common Core States Standards Initiative, 2012). MoNE also explains educational objectives with skills for mathematics education as preparation for life by mathematical capability, mathematical process skills (problem solving, communication, analytical thinking, etc.), using mathematics knowledge in solving real life problems, using mathematics in vocational life, exploring mathematics in nature, art, and social system (MoNE, 2011, 6-8). So, in the light of findings, MoNE should keep on those skills which are needed in social science education. Furthermore, some research studies give certain skills like questioning, reasoning, understanding cause and effect relations, analytical reasoning skills for law and psychology students (Çelikel,1996; Öztürk, 2010; Ansay, 1969; Vice Provost for Undergraduate Education, 2007) as a psychology student should have critical thinking skills and research competence (Cherry, 2013). The findings are also line with the study of (McGovern, Furumoto, Halpern, Kimble, & McKeachie, 1991), which explains psychology department's needed skills as thinking skills, language skills, information gathering and synthesis skills, and research methods and statistical skills. Besides, for professional life of a student graduated from psychology, a skill-based educational life is more valuable than courses taken (Edwards & Smith, 1988; Murray, 1997).

Table 28
Important mathematical skills across the departments

Mathematical problem solving skills	PHL
Mathematical modeling	PHL
Mathematical reasoning	PHL
Mathematical communication	PHL
Mathematical relations	PHL
Mathematical representations	PHL
Analytical reasoning skills	PHL
Critical thinking skills	PHL

L, H, and P refer to Law, History and Psychology departments, respectively.

Discussion with respect to the institutions

Results of the analyses revealed, for the 9^{th} grades, there is no difference in means of important levels across two universities and industry except logic and mathematical proof methods. Participants from Bilkent University consider that these two topics are very important. For 10^{th} grade and 12^{th} grade, no differences were found among institutions, but 11^{th} grade statistics topics are very important for METU. It is an essential result that there is no much difference between institutions. Two universities and the industry people gave the similar mean scores. In this way, if high school mathematics curriculum is differentiated by topics according to departments, there is no need to study different curricula depending on universities. That is, only one differentiated curriculum can be conducted for all institutions.

Implication for practice

Based on findings of the study there are some implications for high school mathematics curriculum, teachers, curriculum developers, and schools:

- Differentiated curriculum does not seem much suitable for social science students at 9th grade, there can be core mathematics courses except geometry for all social science departments. With regard to analyses, there is no difference in importance levels of mathematics topics among social science departments. Since geometry topics are reported as non-important, geometry topics might be elective courses for social science students. As a result of analysis, 9^{th} grade mathematics topics and IBDP statistics topics seem to be enough for students who will prefer a social science program in university. 10^{th}, 11^{th}, 12^{th} grade level mathematics topics are not considered as important for these students. All in all, those who are willing to choose a social science department in university education can learn only 9^{th} grade mathematics topics to be successful at university and other courses were found to be not so important for their professional life.

- When websites of universities are examined, psychology students have generally calculus and advanced statistics courses, law students have in general logic, statistics, accounting, and economics courses, but students who study in history department at university do not have any mathematics courses for their careers. While first year curriculum of law and psychology departments in Turkey promote on the findings of the present study, which might mean universities need to prepare students with some mathematics courses coming from high school during first year, history does not support students with any mathematics courses. Thus, psychology students should focus most on statistics topics, but law students should concentrate on counting and statistics topics. However, with regard to findings of the study history department students should come prepared with knowledge of logic, mathematical proof methods, sets, relations, rate and proportion, proof by induction and proof methods, basic probability concepts, statistics- data notation, Statistics- central tendency and dispersion, drawing and interpreting function concept and some IB statistics topics that our national curriculum does not have, statistical distribution, significance and hypothesis testing, and correlation and regression. Therefore, some IB statistics topics should involve our national curriculum according to department needs for professional life.
- Schools should encourage students to choose mathematics courses according to needs for further education.
- Students who will study in any social science department at university should not learn all mathematics topics in current high school mathematics topics. Similarly, there is a study which explains mathematics topics and skills in

high school for preparation of engineering professions (Başaran, 2013). So, curriculum designers should develop a high school curriculum which includes topics with respect to students needs for professional life and at university.

Implication for research

There are some implications for further research:

- The present study included only topics of high school mathematics curriculum. More detailed studies covering subheadings of topics may provide additional information.
- Quantitative research on some focus groups to gain additional understanding about the relationship between secondary and higher education.
- Topics covered by GCSE (General Certificate of Secondary Education), but not in MoNE and IBDP can be investigated in importance levels for social sciences education in higher education.

Limitations

The present study uses three social departments (law, psychology and history). Thus a limited sample of social science departments may reduce the generalization capability for the findings. This study can be repeated applying more than 50 social scientists and at universities in other parts of Turkey. Also, a relatively small number of participants is another factor that limits generalization. Even though participants included both university staff and people from the industry, their representativeness for their respective populations was not checked. As another limitation, this study was conducted by three social science departments, so it will be useful to study with other social science departments as well. In addition, the study can be repeated for other areas of science at universities.

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APPENDICES

Appendix A: The survey in Turkish

Sayın Öğretim Elemanı;

Bu çalışmanın amacı liseden gelen öğrencilerin sosyal bilimler alanlarında (hukuk, psikoloji, tarih) üniversite eğitimine hazır gelmeleri ve sosyal bilimler eğitiminde daha başarılı olmaları için sahip olmaları gereken matematiksel bilgi ve becerilerin ne olduğunu belirlemektir. Çalışmanın bulgularının matematik müfredatı planlayıcılarına yol gösterici olacağını umuyoruz. Çalışmaya katıldığınız ve zaman ayırdığınız için öncelikle teşekkür ediyoruz.

Millî Eğitim Bakanlığı (MEB) ulusal matematik müfredatında yer alan konular ve MEB müfredatında yer almayan bazı matematik konuları ve beceriler aşağıda verilmiştir. Sosyal bilimler eğitiminde "öğrencilerimin daha başarılı olmaları için ya da daha iyi sosyal bilimci olmaları için liseden şu alanlarda daha yetkin olarak gelmelerini isterdim" diyeceğiniz konuları bu ankette belirtmenizi istiyoruz. Ankette cevaplarınızı her konu veya beceri alanı için seçeneklerden bir tanesini işaretleyerek belirtiniz.

Bazı matematiksel konular doğrudan sosyal bilimler eğitiminde kullanılmasa da diğer matematiksel kavramlar için ön-öğrenme sağlayabilir. Bu çeşit konuları seçeneklerin altında yer alan boşluklara yorum ekleyerek belirtebilirsiniz. Burada yazılmayan ama sizin eklemeyi düşündüğünüz matematiksel konu başlığı ya da beceri varsa, lütfen onları da bölümlerin sonunda ayrılan yerlere yazınız.

Bu çalışma Bilkent Üniversitesi Eğitim Fakültesi'nden Yard. Doç. Dr. İlker Kalender gözetmenliğinde mastır programı öğrencisi Gülümser Özalp tarafından ortaklaşa yürütülmektedir. Bu anket yaklaşık olarak 15 dakika zamanınızı alacaktır. Size özel bilgiler gizlilikle muhafaza edilecek ve sadece çalışma ekibi tarafından kullanılacaktır.

Katılımcının:

Akademik ünvanı:
Üniversite:
Bölüm:
E-posta adresi:

A. Matematik Bilgisi

Aşağıda MEB matematik müfredatında yer alan konular ile birlikte MEB müfredatında yer almayan bazı matematik konuları bulunmaktadır. Eğer herhangi bir konunun alanınızla dolaylı olarak ilgili olduğunu düşünüyorsanız ya da yorum eklemek isterseniz "açıklama" kısmına belirtebilirsiniz.

	Hiç önemli değil	Önemli değil	Kararsızım	Önemli	Çok önemli
1. Mantık (önermeler, doğruluk tabloları, vb.)	❍	❍	❍	❍	❍
Açıklama:					
2. Matematiksel ispat yöntemleri (Tümevarım, olmayana ergi, vb.)	❍	❍	❍	❍	❍
Açıklama:					
3. Kümeler (ve kümelerde işlemler)	❍	❍	❍	❍	❍
Açıklama:					
4. Bağıntı (kümeler arası bağıntılar)	❍	❍	❍	❍	❍
Açıklama:					
5. Fonksiyon kavramı (fonksiyonların tanım ve görüntü kümesi, fonksiyonlarda işlemler)	❍	❍	❍	❍	❍
Açıklama:					
6. Modüler aritmetik (onluk tabandan farklı yazılan sayılar)	❍	❍	❍	❍	❍
Açıklama:					
7. Üslü Sayılar Köklü sayılar	❍	❍	❍	❍	❍
Açıklama:					
8. Tamsayılarda bölünebilme	❍	❍	❍	❍	❍
Açıklama:					
9. Oran / orantı	❍	❍	❍	❍	❍
Açıklama:					

10. Polinomlar (polinomlarda işlemler ve çarpanlara ayırma)	❍	❍	❍	❍	❍
Açıklama:					
11. İkinci dereceden denklemler ve fonksiyonlar	❍	❍	❍	❍	❍
Açıklama:					
12. Trigonometrik oranlar(sinüs, kosinüs, vb.)	❍	❍	❍	❍	❍
Açıklama:					
13. Trigonometri (dar açı oranları, trigonometrik fonksiyonlar, toplam ve fark formülleri, trigonometrik denklemler)	❍	❍	❍	❍	❍
Açıklama:					
14. Karmaşık sayılar	❍	❍	❍	❍	❍
Açıklama:					
15. Üstel denklemler ve fonksiyonlar	❍	❍	❍	❍	❍
Açıklama:					
16. Logaritmik denklemler ve fonksiyonlar, doğal logaritma	❍	❍	❍	❍	❍
Açıklama:					
17. Tümevarımla ispat ve ispat yöntemleri	❍	❍	❍	❍	❍
Açıklama:					
18. Diziler (aritmetik ve geometrik diziler)	❍	❍	❍	❍	❍
Açıklama:					
19. Matris, matris işlemleri ve determinantlar	❍	❍	❍	❍	❍
Açıklama:					
20. Doğrusal denklem sistemleri ve uygulamaları	❍	❍	❍	❍	❍
Açıklama:					

21. Sayma yöntemleri (permütasyon ve kombinasyon)	❍	❍	❍	❍	❍
Açıklama:					
22. Paskal üçgeni ve Binom açılımı	❍	❍	❍	❍	❍
Açıklama:					
23. Limit ve süreklilik	❍	❍	❍	❍	❍
Açıklama:					
24. Fonksiyonların grafiklerinin çizilmesi ve yorumlanması	❍	❍	❍	❍	❍
Açıklama:					
25. Türev ve türev uygulamaları	❍	❍	❍	❍	❍
Açıklama:					
26. İntegral (belirsiz integral, belirli integral, integral uygulamaları)	❍	❍	❍	❍	❍
Açıklama:					
27. Analitik düzlemde vektörler, vektör işlemleri ve uygulamaları	❍	❍	❍	❍	❍
Açıklama:					
28. Uzayda (üç boyutlu) vektörler, vektör işlemleri ve uygulamaları	❍	❍	❍	❍	❍
Açıklama:					
29. Analitik düzlemde doğrunun ve çemberin özellikleri	❍	❍	❍	❍	❍
Açıklama:					
30. Analitik düzlemde uzaklık ve uygulamaları	❍	❍	❍	❍	❍
Açıklama:					

31. Uzayda düzlem ve analitik özellikleri	❍	❍	❍	❍	❍
Açıklama:					
32. Koniklerin analitik incelemesi (parabol, hiperbol ve elips)	❍	❍	❍	❍	❍
Açıklama:					
33. Sentetik geometri: Nokta, doğru, açı, ışın, düzlem, uzay	❍	❍	❍	❍	❍
Açıklama:					
34. Sentetik geometri: Çokgenlerin ve üçgenlerin açıları ve alanları	❍	❍	❍	❍	❍
Açıklama:					
35. Üçgenlerde benzerlik teoremleri	❍	❍	❍	❍	❍
Açıklama:					
36. Daire ve daire diliminin alanı, çemberin açıları, çevre uzunluğu	❍	❍	❍	❍	❍
Açıklama:					
37. Silindir, koni, küre, prizma ve piramit ve özellikleri	❍	❍	❍	❍	❍
Açıklama:					
38. Düzlemde dönüşümler (öteleme, dönme, yansıma)	❍	❍	❍	❍	❍
Açıklama:					
39. Geometride teorem ispatları	❍	❍	❍	❍	❍
Açıklama:					
40. Düzlemde kaplama ve süslemeler (Escher süslemeleri)	❍	❍	❍	❍	❍
Açıklama:					

41. Temel olasılık kavramları (deney, çıktı, örneklem, koşullu olasılık, bağımsız ve bağımlı olaylar ve diğerleri)	❍	❍	❍	❍	❍
Açıklama:					
42. İstatistik – veri gösterimi (sütun, çizgi, kutu, serpilme, histogram vb. grafikler)	❍	❍	❍	❍	❍
Açıklama:					
43. İstatistik – merkezî eğilim ve yayılma ölçüleri	❍	❍	❍	❍	❍
Açıklama:					
44. Sonlu rastgele değişkenler	❍	❍	❍	❍	❍
Açıklama:					
45. İstatistiksel dağılımlar (binom, possion, ki-kare, ve normal dağılımlar)	❍	❍	❍	❍	❍
Açıklama:					
46. Bayes teoremi	❍	❍	❍	❍	❍
Açıklama:					
47. Anlamlılık ve hipotez testi	❍	❍	❍	❍	❍
Açıklama:					
48. Korelasyon Regresyon	❍	❍	❍	❍	❍
Açıklama:					
49. Faiz, amortisman ve maliyet hesapları	❍	❍	❍	❍	❍
Açıklama:					

Aşağıya lise matematik müfredatına eklenmesini teklif edeceğiniz konuları yazabilirsiniz.

Teklif ettiğiniz konular

	Önemli	Çok önemli
Konu 1:	❍	❍
Konu 2:	❍	❍
Konu 3:	❍	❍

B. Beceriler

Aşağıda bazı matematiksel beceriler ve kısa açıklamaları verilmiştir. Bu becerileri lise eğitimindeki deneyimlerine göre öğrenciler değişik düzeylerde geliştirebilirler. Bunlardan hangilerinin öğrencilerin üniversitede sosyal bilimler alanındaki eğitimlerinde başarılı olmaları için önemli olduğunu seçeneklerden birini işaretleyerek belirtiniz. Boşluk bırakılan yerlere işaretlediğiniz becerinin neden bölümünüz için önemli olduğunu kısaca açıklayınız.

- **Matematiksel problem çözme** (matematiksel kavram ve kuralların sıradan olmayan *problemlerin çözümünde* etkin olarak kullanılabilmesi)

Hiç önemli değil	Önemli değil	Kararsızım	Önemli	Çok önemli
❍	❍	❍	❍	❍

- **Matematiksel modelleme** (matematiksel dil ve kavramları kullanarak, fen, sosyal bilimler, mühendislik, iktisat vb. alanlardan problem durumlarını açıklayan ve öngören *modeller kurulabilmesi*)

Hiç önemli değil	Önemli değil	Kararsızım	Önemli	Çok önemli
❍	❍	❍	❍	❍

- **Matematiksel fikir yürütme** (matematiksel kural, genelleme ve çözümlerin arkasındaki *'neden'lerin anlaşılması*, formül ezberinin ötesine geçilmesi)

Hiç önemli değil	Önemli değil	Kararsızım	Önemli	Çok önemli
❍	❍	❍	❍	❍

- **Matematiksel iletişim (***matematiksel düşüncelerin* standart matematiksel terim ve sembollerle diğer insanların anlayabileceği şekilde *anlatılabilmesi*)

Hiç önemli değil	Önemli değil	Kararsızım	Önemli	Çok önemli
❍	❍	❍	❍	❍

- **Matematiksel bağlantılar** (matematiksel kavramlar, matematikle diğer fen alanları ve matematikle günlük hayat arasında bağlantılar kurulabilmesi)

Hiç önemli değil	Önemli değil	Kararsızım	Önemli	Çok önemli
❍	❍	❍	❍	❍

- **Matematiksel çoklu gösterimler** (bir kavramın, -örneğin fonksiyon- cebir, grafik, tablo, diyagram vb. yöntemlerle çoklu gösterimi ve aradaki geçişlerin ve ilişkilerin kurulabilmesi)

Hiç önemli değil	Önemli değil	Kararsızım	Önemli	Çok önemli
❍	❍	❍	❍	❍

- **Analitik düşünme becerisi** (Bir bütünün işleyişini anlamak için parçalar ve parçalar arasındaki ilişkilerin soyut olarak ayrıştırılabilmesi)

Hiç önemli değil	Önemli değil	Kararsızım	Önemli	Çok önemli
❍	❍	❍	❍	❍

- **Eleştirel düşünme becerisi** (Bir şeyin –argüman, söylem, haber, veya araştırma- geçerliliğini değerlendirmek için sistemli olarak fikir yürütebilme)

Hiç önemli değil	Önemli değil	Kararsızım	Önemli	Çok önemli
❍	❍	❍	❍	❍

Önemli gördüğünüz diğer beceriler

1. ________________

2. ________________

3. ________________

Görüşlerinizi daha detaylı olarak kişisel bir mülakatla paylaşmak ister misiniz? Size bu konuda ulaşabilir miyiz?

❍ Evet
❍ Hayır

Iletişim bilgileriniz

Adınız ve Soyadınız:

Telefon numaranız:

Sizi ne zaman arayabiliriz?

Appendix B: The means and standard deviations of 9th grade mathematics topic across departments

Topic	Department	Mean	Std. Deviation
Logic	History	4.00	1.31
	Law	4.60	0.71
	Psychology	3.76	1.25
	Total	4.22	1.07
Mathematical proof methods	History	3.50	1.20
	Law	4.44	0.58
	Psychology	3.53	0.94
	Total	3.98	0.94
Sets	History	3.13	1.46
	Law	3.24	1.16
	Psychology	3.18	0.88
	Total	3.20	1.11
Function concept	History	2.75	1.04
	Law	3.08	1.12
	Psychology	3.06	1.25
	Total	3.02	1.13
Relations	History	3.50	1.51
	Law	3.24	1.09
	Psychology	3.24	0.83
	Total	3.28	1.07
Modular arithmetic	History	2.38	1.30
	Law	2.32	1.22
	Psychology	2.65	1.00
	Total	2.44	1.15
Exponential numbers and surds	History	2.13	1.36
	Law	2.32	1.22
	Psychology	3.35	1.00
	Total	2.64	1.26
Divisibility of integers	History	2.88	1.46
	Law	3.00	1.35
	Psychology	2.82	1.29
	Total	2.92	1.32
Rate/proportion	History	4.13	0.83
	Law	3.88	1.17
	Psychology	4.29	0.77
	Total	4.06	1.00
Vectors in analytic plane	History	2.75	1.39
	Law	2.28	1.31
	Psychology	2.59	1.33
	Total	2.46	1.31
Line and circle properties	History	2.38	1.60
	Law	2.32	1.22
	Psychology	2.59	1.37
	Total	2.42	1.31
Distance and applications	History	2.63	1.51
	Law	2.36	1.25
	Psychology	2.65	1.32
	Total	2.50	1.30
Synthetic geometry: Point…	History	2.00	1.20
	Law	2.12	1.01
	Psychology	2.65	1.11
	Total	2.28	1.09
Synthetic geometry: Angles…	History	2.25	1.16
	Law	2.40	1.22
	Psychology	2.35	1.22
	Total	2.36	1.19
Cylinder, cone, sphere…	History	2.00	1.20
	Law	2.28	1.31
	Psychology	2.29	1.36
	Total	2.24	1.29
Tessellations on the plane	History	2.00	1.20
	Law	2.00	1.04
	Psychology	2.35	1.17
	Total	2.12	1.10

Appendix C: The means and standard deviations of 10^{th} grade mathematics topic across departments

Topic	Department	Mean	Std. Deviation
Polynomials	History	2.50	1.31
	Law	2.48	1.00
	Psychology	2.71	1.31
	Total	2.56	1.15
Quadratic equations and functions	History	2.63	1.19
	Law	3.24	1.23
	Psychology	3.06	1.34
	Total	3.08	1.26
Trigonometric ratios	History	2.38	0.92
	Law	2.20	1.12
	Psychology	2.35	1.27
	Total	2.28	1.13
Trigonometry	History	2.25	1.04
	Law	2.16	1.07
	Psychology	2.29	1.21
	Total	2.22	1.09
Similarity theorems	History	2.38	1.19
	Law	2.68	1.28
	Psychology	2.59	1.33
	Total	2.60	1.26
Transformations	History	2.25	1.16
	Law	2.08	1.04
	Psychology	2.65	1.37
	Total	2.30	1.18
The proof of theorems in geometry	History	2.25	1.16
	Law	2.60	1.35
	Psychology	2.41	1.28
	Total	2.48	1.28

Appendix D: The means and standard deviations of 11th grade mathematics topic across departments

Topic	Department	Mean	Std. Deviation
Complex numbers	History	2.50	1.31
	Law	2.24	1.09
	Psychology	2.41	1.23
	Total	2.34	1.15
Exponential equations	History	2.13	1.25
	Law	2.16	1.11
	Psychology	2.82	1.19
	Total	2.38	1.18
Logarithmic equations	History	2.25	0.89
	Law	2.08	1.04
	Psychology	2.88	1.27
	Total	2.38	1.14
Proof by induction	History	3.50	1.20
	Law	4.20	1.00
	Psychology	3.59	1.18
	Total	3.88	1.12
Sequences	History	3.00	1.31
	Law	2.72	1.28
	Psychology	3.18	0.88
	Total	2.92	1.16
Matrices	History	2.75	1.16
	Law	2.08	1.26
	Psychology	2.76	1.20
	Total	2.42	1.25
Linear equation systems	History	2.75	1.16
	Law	2.80	1.29
	Psychology	3.12	1.22
	Total	2.90	1.23
Counting methods	History	3.00	0.93
	Law	3.04	1.27
	Psychology	3.35	1.27
	Total	3.14	1.21
Pascal triangle and Binomial	History	2.50	0.93
	Law	2.28	1.24
	Psychology	2.53	1.28
	Total	2.40	1.20
Analytical investigation of conics	History	2.00	1.20
	Law	2.20	1.19
	Psychology	2.24	1.20
	Total	2.18	1.17
Circular region and area…	History	2.00	1.20
	Law	2.56	1.39
	Psychology	2.53	1.33
	Total	2.46	1.33
Basic probability concepts	History	3.88	0.64
	Law	3.76	1.09
	Psychology	4.53	0.51
	Total	4.04	0.92
Statistics - Data notation	History	4.00	0.76
	Law	3.28	1.37
	Psychology	4.88	0.33
	Total	3.94	1.25
Statistics - central tendency and dispersion	History	3.25	1.58
	Law	3.04	1.40
	Psychology	4.82	0.53
	Total	3.68	1.45

Appendix E: The means and standard deviations of 12th grade mathematics topic across departments

Topic	Department	Mean	Std. Deviation
Limit and continuity	History	2.50	1.07
	Law	2.28	1.14
	Psychology	2.71	1.21
	Total	2.46	1.15
Drawing and interpreting…	History	3.25	1.16
	Law	2.72	1.31
	Psychology	3.35	1.27
	Total	3.02	1.29
Derivatives	History	2.88	0.83
	Law	2.40	1.26
	Psychology	2.76	1.39
	Total	2.60	1.25
Integration	History	2.38	1.19
	Law	2.04	1.06
	Psychology	2.65	1.54
	Total	2.30	1.27
Vectors	History	2.50	1.07
	Law	2.12	1.17
	Psychology	2.59	1.37
	Total	2.34	1.22
Plane in space	History	2.25	1.16
	Law	2.20	1.00
	Psychology	2.53	1.33
	Total	2.32	1.13

Appendix F: The means and standard deviations of IBDP mathematics topic across departments

Topic	Department	Mean	Std. Deviation
Finite random variables	History	2.88	1.36
	Law	2.56	1.19
	Psychology	3.47	1.23
	Total	2.92	1.28
Statistical distribution	History	3.25	1.16
	Law	2.56	1.23
	Psychology	4.76	0.44
	Total	3.42	1.42
Bayes theorem	History	2.75	0.71
	Law	2.84	0.99
	Psychology	3.41	1.12
	Total	3.02	1.02
Significance and hypothesis testing	History	3.38	1.30
	Law	2.92	1.15
	Psychology	4.82	0.39
	Total	3.64	1.31
Correlation and regression	History	3.38	1.30
	Law	2.88	1.17
	Psychology	4.88	0.33
	Total	3.64	1.34
Interest, depreciation and cost	History	2.88	1.36
	Law	3.68	1.22
	Psychology	3.12	1.36
	Total	3.36	1.31

Appendix G: The means and standard deviations of mathematical skills across departments

Skill	Department	Mean	Std. Deviation
Mathematical problem solving	History	3.43	0.98
	Law	4.36	0.76
	Psychology	4.13	0.72
	Total	4.15	0.82
Mathematical modeling	History	3.43	0.79
	Law	3.88	0.97
	Psychology	3.88	0.89
	Total	3.81	0.91
Mathematical reasoning	History	4.00	1.00
	Law	4.52	0.77
	Psychology	4.13	0.72
	Total	4.31	0.80
Mathematical communication	History	3.71	1.38
	Law	3.64	1.19
	Psychology	4.19	0.83
	Total	3.83	1.12
Mathematical relations	History	4.00	1.41
	Law	4.08	1.00
	Psychology	4.19	0.98
	Total	4.10	1.04
Mathematical representations	History	3.14	1.07
	Law	3.24	1.33
	Psychology	4.25	0.86
	Total	3.56	1.24
Analytical reasoning skills	History	4.14	0.69
	Law	4.68	0.69
	Psychology	4.69	0.60
	Total	4.60	0.68
Critical thinking skills	History	4.57	0.79
	Law	4.84	0.37
	Psychology	4.75	0.58
	Total	4.77	0.52

Appendix H: The means and standard deviations of 9th grade mathematics topics across institutions

Topic	Institution	Mean	Std. Deviation
Logic	METU	3.87	1.19
	Bilkent	4.60	0.76
	Industry	3.80	1.32
	Total	4.22	1.07
Mathematical proof methods	METU	3.47	1.13
	Bilkent	4.32	0.75
	Industry	3.90	0.74
	Total	3.98	0.94
Relations	METU	3.07	0.80
	Bilkent	3.60	1.19
	Industry	2.80	0.92
	Total	3.28	1.07
Sets	METU	3.07	0.88
	Bilkent	3.40	1.26
	Industry	2.90	0.99
	Total	3.20	1.11
Function concept	METU	2.93	1.33
	Bilkent	2.92	1.00
	Industry	3.40	1.17
	Total	3.02	1.13
Modular arithmetic	METU	2.33	0.98
	Bilkent	2.52	1.26
	Industry	2.40	1.17
	Total	2.44	1.15
Exponential numbers and surds	METU	3.13	1.13
	Bilkent	2.32	1.22
	Industry	2.70	1.42
	Total	2.64	1.26
Divisibility of integers	METU	2.53	1.13
	Bilkent	3.08	1.35
	Industry	3.10	1.52
	Total	2.92	1.32
Rate/proportion	METU	4.20	0.86
	Bilkent	3.96	1.02
	Industry	4.10	1.20
	Total	4.06	1.00
Vectors in analytic plane	METU	2.53	1.41
	Bilkent	2.28	1.14
	Industry	2.80	1.62
	Total	2.46	1.31
Line and circle properties	METU	2.40	1.45
	Bilkent	2.24	1.13
	Industry	2.90	1.52
	Total	2.42	1.31
Distance and applications in analytic plane	METU	2.47	1.41
	Bilkent	2.32	1.11
	Industry	3.00	1.56
	Total	2.50	1.30
Synthetic geometry: Point…	METU	2.53	1.25
	Bilkent	2.04	0.89
	Industry	2.50	1.27
	Total	2.28	1.09
Synthetic geometry: Angles and areas…	METU	2.07	1.16
	Bilkent	2.44	1.23
	Industry	2.60	1.17
	Total	2.36	1.19
Cylinder, cone, sphere…	METU	1.93	1.28
	Bilkent	2.32	1.25
	Industry	2.50	1.43
	Total	2.24	1.29
Tessellations on the plane	METU	2.13	1.19
	Bilkent	2.04	0.98
	Industry	2.30	1.34
	Total	2.12	1.10

Appendix I: The means and standard deviations of 10^{th} grade mathematics topics across institutions

Topic	Institution	Mean	Std. Deviation
Quadratic equations and functions	METU	2.67	1.40
	Bilkent	3.20	1.04
	Industry	3.40	1.51
	Total	3.08	1.26
Trigonometric ratios	METU	2.13	1.19
	Bilkent	2.36	1.08
	Industry	2.30	1.25
	Total	2.28	1.13
Trigonometry	METU	2.13	1.25
	Bilkent	2.24	0.97
	Industry	2.30	1.25
	Total	2.22	1.09
Polynomials	METU	2.40	1.35
	Bilkent	2.76	1.09
	Industry	2.30	0.95
	Total	2.56	1.15
Similarity theorems for triangles	METU	2.33	1.35
	Bilkent	2.60	1.22
	Industry	3.00	1.25
	Total	2.60	1.26
Transformations on the plane	METU	2.33	1.40
	Bilkent	2.28	1.02
	Industry	2.30	1.34
	Total	2.30	1.18
The proof of theorems in geometry	METU	2.20	1.32
	Bilkent	2.52	1.23
	Industry	2.80	1.40
	Total	2.48	1.28

Appendix J: The means and standard deviations of 11th grade mathematics topics across institutions

Topic	Institution	Mean	Std. Deviation
Complex numbers	METU	2.13	1.19
	Bilkent	2.36	1.11
	Industry	2.60	1.26
	Total	2.34	1.15
Exponential equations and functions	METU	2.60	1.24
	Bilkent	2.16	1.07
	Industry	2.60	1.35
	Total	2.38	1.18
Logarithmic equations	METU	2.67	1.35
	Bilkent	2.20	0.96
	Industry	2.40	1.26
	Total	2.38	1.14
Proof by induction and proof methods	METU	3.47	1.41
	Bilkent	4.16	0.99
	Industry	3.80	0.79
	Total	3.88	1.12
Sequences	METU	2.93	1.03
	Bilkent	3.00	1.15
	Industry	2.70	1.42
	Total	2.92	1.16
Matrices	METU	2.53	1.30
	Bilkent	2.32	1.22
	Industry	2.50	1.35
	Total	2.42	1.25
Linear equation systems	METU	2.80	1.26
	Bilkent	2.88	1.20
	Industry	3.10	1.37
	Total	2.90	1.23
Counting methods	METU	3.07	1.33
	Bilkent	3.04	1.21
	Industry	3.50	1.08
	Total	3.14	1.21
Pascal triangle and Binomial formula	METU	2.20	1.15
	Bilkent	2.28	0.98
	Industry	3.00	1.63
	Total	2.40	1.20
Analytical investigation of conics	METU	2.00	1.20
	Bilkent	2.08	1.00
	Industry	2.70	1.49
	Total	2.18	1.17
Circular region and area	METU	2.20	1.32
	Bilkent	2.56	1.36
	Industry	2.60	1.35
	Total	2.46	1.33
Basic probability concepts	METU	4.40	0.63
	Bilkent	3.92	0.86
	Industry	3.80	1.32
	Total	4.04	0.92
Statistics - data notation	METU	4.67	0.72
	Bilkent	3.48	1.33
	Industry	4.00	1.25
	Total	3.94	1.25
Statistics - central tendency and dispersion	METU	4.60	0.83
	Bilkent	3.12	1.42
	Industry	3.70	1.64
	Total	3.68	1.45

Appendix K: The means and standard deviations of 12th grade mathematics topics across institutions

Topic	Institution	Mean	Std. Deviation
Limit and continuity	METU	2.60	1.18
	Bilkent	2.44	1.08
	Industry	2.30	1.34
	Total	2.46	1.15
Drawing and interpreting functions graphs	METU	3.00	1.13
	Bilkent	2.88	1.30
	Industry	3.40	1.51
	Total	3.02	1.29
Derivatives	METU	2.53	1.19
	Bilkent	2.64	1.35
	Industry	2.60	1.17
	Total	2.60	1.25
Integration	METU	2.33	1.45
	Bilkent	2.24	1.23
	Industry	2.40	1.17
	Total	2.30	1.27
Vectors (three dimensional)	METU	2.47	1.41
	Bilkent	2.16	0.94
	Industry	2.60	1.58
	Total	2.34	1.22
Plane in space and analytic properties	METU	2.40	1.35
	Bilkent	2.16	0.90
	Industry	2.60	1.35
	Total	2.32	1.13

Appendix L: The means and standard deviations of IBDP mathematics topics across institutions

Topic	Institution	Mean	Std.
Finite random variables	METU	3.27	1.16
	Bilkent	2.68	1.38
	Industry	3.00	1.15
	Total	2.92	1.28
Statistical distribution	METU	4.53	0.74
	Bilkent	2.92	1.47
	Industry	3.00	1.15
	Total	3.42	1.42
Bayes theorem	METU	3.27	1.16
	Bilkent	2.88	1.01
	Industry	3.00	0.82
	Total	3.02	1.02
Significance and hypothesis testing	METU	4.60	0.74
	Bilkent	3.36	1.29
	Industry	2.90	1.29
	Total	3.64	1.31
Correlation and regression	METU	4.67	0.72
	Bilkent	3.28	1.34
	Industry	3.00	1.25
	Total	3.64	1.34
Interest, depreciation and cost	METU	3.07	1.39
	Bilkent	3.44	1.42
	Industry	3.60	0.84
	Total	3.36	1.31

Appendix M: The means and standard deviations of mathematical skills across institutions

Skill	Institution	Mean	Std. Deviation
Mathematical problem solving	METU	3.93	0.92
	Bilkent	4.33	0.76
	Industry	4.00	0.82
	Total	4.15	0.82
Mathematical modeling	METU	3.71	1.07
	Bilkent	3.75	0.85
	Industry	4.10	0.88
	Total	3.81	0.91
Mathematical reasoning	METU	4.00	0.96
	Bilkent	4.50	0.59
	Industry	4.30	0.95
	Total	4.31	0.80
Mathematical communication	METU	3.93	1.27
	Bilkent	3.88	0.85
	Industry	3.60	1.51
	Total	3.83	1.12
Mathematical relations	METU	4.14	1.23
	Bilkent	4.17	0.87
	Industry	3.90	1.20
	Total	4.10	1.04
Mathematical representations	METU	4.07	1.14
	Bilkent	3.54	1.06
	Industry	2.90	1.52
	Total	3.56	1.24
Analytical reasoning skills	METU	4.64	0.63
	Bilkent	4.67	0.70
	Industry	4.40	0.70
	Total	4.60	0.68
Critical thinking skills	METU	4.79	0.58
	Bilkent	4.83	0.38
	Industry	4.60	0.70
	Total	4.77	0.52